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An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

Designs, Production DRAWINGS, TRACINGS, etc. Prepared for all kinds Engineering work. Patent Drawings. J. HAMMOND, 63, Summer Road, East Molesey, Surrey. 'Phone: Esher 341. 1273

THE GLASGOW ROLLING STOCK AND PLANT WORKS. Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od3382

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54 & 55, FETTER LANE, LONDON, E.C.4. 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

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Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 939
See half-page Advertisement, page 66, June 8.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. B. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
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Correspondence Courses for Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.E.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1401

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Fuel Economy.—Well-known Expert is OPEN to ACCEPT STUDENTS for Correspondence Course of Instruction in Combustion Engineering, etc.—Particulars, fees, etc., write IGNITION, 171, Warminster Road, Sheffield. A 746

TENDERS.

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Tenders for the Supply of FOUR MOTOR ESCAPE VANS for the London Fire Brigade. The type of van required may be seen by appointment on application to the Chief Officer, London Fire Brigade, 94, Southwark Bridge Road, S.E.1.

Forms of Tender, with schedules annexed, can be obtained on application to the Clerk of the Council, at the County Hall, Westminster Bridge, S.E.1, on payment of the sum of £1 1s., which amount will, after the Council or its Committee shall have come to a decision upon the tenders received, be returned to the tenderer, provided he shall have sent in a *bona fide* Tender and shall not have withdrawn the same.

Tenders must be addressed to the Clerk of the Council, and delivered at the County Hall, Westminster Bridge, S.E.1, not later than Four p.m. on Monday, 9th July, 1923. No Tender will be received after that time.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. A 857

METROPOLITAN BOROUGH OF SHOREDITCH.

ELECTRICITY SUPPLY DEPARTMENT.

The Council invite

Tenders for the Supply, DELIVERY, ERECTION, etc., of the following PLANT:

One Water Tube Boiler of not less than 40,000 lbs. evap. cap.
Two Superheaters.
Coal Bunkers and Conveying Plant.
One 1,500 Kw. Converter.

Specifications, Drawings, and Forms of Tender, may be had upon application to the Borough Electrical Engineer, Electricity Supply Department, Coronet Street, Shoreditch, N.E.1, on payment, in each case, of £1 1s., which will be refunded upon receipt of a *bona fide* Tender.

Sealed Tenders, forwarded in accordance with the instructions given with each specification, are to be delivered not later than noon on Wednesday, the 4th July, 1923.

The Council do not bind themselves to accept the lowest or any Tender.

C. NEWTON RUSSELL,
Borough Electrical Engineer.
Coronet Street,
Shoreditch, N.E.1. A 867

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY of the following MATERIAL for the Morwell Power Scheme.

Copies of Tender Form and Specification, etc., will be available for inspection and purchase upon application to:—

THE AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 23/33—TRANSFORMERS.

CHARGE:—10s. for two copies of Tender Form, Specification, Contract, Conditions, etc., complete. This charge will be returned on receipt of a *bona fide* Tender.

A third or any further copies will be supplied for the sum of 5s. each, but this charge is not returnable.

PRELIMINARY DEPOSIT:—A preliminary deposit of £50 is required to be lodged with each Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed forms, properly addressed and endorsed, must be delivered to the undersigned in Melbourne, not later than noon, 25th August, 1923.

R. LIDDELOW.
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. A 809

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Tenders for the Removal and Disposal by barge of ASHES from the POWER STATION at East Greenwich for alternative periods of six and twelve calendar months, commencing on 1st August, 1923.

Particulars and Forms of Tender may be obtained from the General Manager, London County Council Tramways, Victoria Embankment, W.C.2.

No Tender will be considered if received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 2nd July, 1923.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. A 875

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

STEELWORK FOR BRIDGES (Approx. 17¾ tons).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Bridgework," must be left with the undersigned not later than Twelve Noon on Friday, the 6th July, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
14th June, 1923. A 856

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

		Fee for Specification.
1.	Mild Steel Bars, Sections, &c. ...	£1
2.	Mantles for Lamps	5/-
3.	Wicks, &c.	5/-
4.	India-Rubber Hose Pipes, Sheets, &c.	7/6
5.	Paints, Drysalteries, &c.	10/-
6.	Carriage Door Handles, Hinges, &c.	7/6
7.	Lamp Glasses, &c.	2/6
8.	Expanded Metal	2/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Mild Steel Bars, Sections, &c.," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 3rd July, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.
Company's Offices,
48, Copthall Avenue, E.C.2.
London, 20th June, 1923. A 897

APPOINTMENTS OPEN.

UNIVERSITY OF DURHAM.

ARMSTRONG COLLEGE,
NEWCASTLE-UPON-TYNE.

LECTURER IN CIVIL ENGINEERING.

The Council of Armstrong College invite

Applications for a Lectureship in CIVIL ENGINEERING.

Candidates must be qualified to teach Surveying and have practical experience and a University degree. Salary £350 to £400 per annum according to qualifications. Duties commence 1st October, 1923. Ten copies of applications, and of not more than three testimonials, should reach the undersigned not later than 7th July, 1923.

J. Y. T. GRHIG,
Registrar,
Armstrong College. A 787

WEST HAM MUNICIPAL COLLEGE,
Romford Road, Stratford, E.15.

Applications are Invited for the post of FULL-TIME ASSISTANT TEACHER in the DEPARTMENT of ENGINEERING, from candidates with University Degree and Works experience. Salary in accordance with the Technical Burnham Scale for the London Area, less 5 per cent., and subject to deduction for superannuation.

Forms of Application may be obtained from the PRINCIPAL, and should be returned not later than the 5th July, 1923.

GEO. H. HILLEARY,
Town Clerk. A 816

Required, for Modern Foundry, engaged in locomotive and general work, an EXPERIENCED MANAGER. State terms and present employment.—Address, A 904, Offices of ENGINEERING.

Works Manager Wanted, for Small Engineering Works in South of England, employing about 60 hands; general engineering repairs, fitting shop, iron and brass foundry, forge, etc. Must be experienced Mechanical Engineer, good organizer and time supervisor, accustomed to Estimating.—Address, stating full particulars, experience, age and salary, A 850, Offices of ENGINEERING.

SOUTH INDIAN RAILWAY.

A Works Manager is Required for the Locomotive and Carriage and Wagon Workshops of this Railway at Trichinopoly, now in course of erection.

The salary of the appointment, which, in the first instance, will be for three years, but may be made permanent, commences on date of embarkation for India, and will be within the limits of Rupees 1000 and Rupees 1500 per mensem, according to qualifications.

The Officer will receive the Benefits of Membership of the Railway Provident Institution, the funds of which are lodged with the Government of India.

The passage to India will be paid by the Company, who will also pay the return passage if the employment of the Officer is terminated on the expiry of the first period of service provided for.

The rules governing leave and gratuity may be ascertained on application.

Candidates, who should be between the ages of 30 and 40, should have had a first-class education, with subsequent training and experience in Railway or Manufacturing Workshops, have held administrative positions in engineering workshops, and be well versed in modern methods of workshop procedure and organisation.

Forms, upon which applications must be made, may be obtained on written request to Messrs. Robert White & Partners, 3, Victoria Street, London, S.W.1, the Consulting Engineers to the Company.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
18th June, 1923. A 870

Wanted, Assistant, Qualified to survey large factory establishment, layout dimension and estimate capital cost of installing and operating, expenses of heating plant for building and process heating on low pressure feed with vacuum return system. Experience, qualifications and wage expected.—Address, HEATING, WM. PORTEOUS & Co., Advertising Agents, Glasgow. A 772

Metallurgist Wanted for Responsible Position. Preference will be given to applicant having works experience and ability to carry out original investigation.—Address, stating briefly experience and qualifications, A 804, Offices of ENGINEERING.

Wanted, at Once, Temporary ENGINEERING ASSISTANTS with good experience in design of docks and heavy masonry, also assistant experienced in design of reinforced concrete wharves. Preference given to ex-Service men.—Apply, giving full particulars of experience, age, salary required, when disengaged, and enclosing copy of recent testimonials, to CIVIL ENGINEER-IN-CHIEF, Admiralty, S.W.1. A 859

Engineer Required at the Royal Aircraft Establishment, South Farnborough, to assist in aerodynamic experimental work upon aeroplanes in flight. Applicants must have had training in Engineering Science to the standard of B.Sc. degree, and experience in works and drawing office. Must be willing to fly as observer and be medically fit for flying. Salary from 60s. per week plus Civil Service bonus (total remuneration at present £4 17s. 3d.) to 80s. per week plus Civil Service bonus (present total remuneration £6 4s. 4d.) Preference will be given to ex-service men.

Application should be forwarded to the SUPERINTENDENT, ROYAL AIRCRAFT ESTABLISHMENT, South Farnborough. A 901

Assistant Engineers REQUIRED by the GOVERNMENT of HONG KONG for the HARBOUR WORKS DEPARTMENT for three years' service with possible extension. Salary £460, rising to £500 by annual increments of £20. Salary is paid in dollars at Government rate of exchange, at present fixed at 2/- to the dollar. Free passages. Candidates, age 24 to 30, must be unmarried and excellent draughtsmen, well qualified in levelling, land and marine surveying and sounding. Must have been regularly educated and trained as Civil Engineers in the special branch of Dock and Harbour Engineering, and have had subsequent experience in the design and construction of general Dock and Harbour Works. Should be connected with the Institution of Civil Engineers and have passed the examination, qualifying for election as Associate Members, or possess an University Degree or Engineering College Diploma exempting therefrom.

Apply at once by letter, stating age and giving particulars of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/Hong Kong 11974. A 858

COUNTY BOROUGH OF NEWPORT.

BOROUGH AND WATERWORKS ENGINEER'S DEPARTMENT.

The Corporation invite

Applications for the Position of:—

(1).—CHIEF ENGINEERING ASSISTANT, to take Charge of the Drawing Office and to exercise Supervision over the Construction of Engineering Works. Candidates should have had a varied experience of Civil Engineering Works and have passed the qualifying examination for Associate Membership of the Institution of Civil Engineers.

(2).—SPECIAL TEMPORARY ASSISTANT in connection with a scheme for the erection of Public Slaughterhouses and Cattle Markets. Candidates should set out in detail their experience of this class of work.

The Salary attaching to both appointments is £333 2s. 6d. per annum, increasing by one increment to £415 5s. per annum.

Applications, endorsed "Chief Engineering Assistant," or "Special Assistant," as the case may be, stating age, experience and qualifications, together with copies of not more than three recent testimonials, to be delivered at my office before Noon on Wednesday, 27th June, 1923.

W. LIONEL JENKINS,
Borough and Waterworks Engineer.
Town Hall,
Newport, Mon.
14th June, 1923. A 853

Traveller for Reinforced Concrete Roads. London district. £360 p.a. and commission.—Address, A 879, Offices of ENGINEERING.

Wanted, Competent General Engineer, able to do draughting.—Address, A 888, Offices of ENGINEERING.

One Responsible Engineer REQUIRED in each works as Agent for our Course of Tuition in Automobile Engineering.
SOUTHERN ENGINEERING INSTITUTE,
Newdigate, Surrey. A 752

Sugar. — Junior Assistant ENGINEER REQUIRED for large Sugar Factory in Peru. Contract three years, passage paid, commencing salary £25 monthly, increasing £60 each year, free quarters, £8 monthly allowance in lieu of board.—Write, stating age, height, where educated, and full details of experience to Z. K. 863, care DEACONS, Leadenhall St., London. A 863

SURREY COUNTY COUNCIL.

HIGHWAYS AND BRIDGES DEPARTMENT.

Applications are Invited for the APPOINTMENT of FIRST ASSISTANT ENGINEER, who is required to be a Corporate Member of Institution of Civil Engineers, to have had a thorough experience in surveying, preparation of drawings, Specifications and quantities for road and bridge construction and in the repair of roads, asphaltic materials, and not over 40 years of age.

The appointment will be ranked as an officer of the third class, carrying a salary commencing at £295 per annum, rising by annual increments, subject to approved service, of £15 to £500, and will be an Established Post under the Council's Superannuation Scheme. It will be determinable at the pleasure of the Council, at three months' notice in writing on either side, and be subject to the standing orders of the Council relating to whole time duty, travelling and subsistence allowances and the other conditions of the service. Applications should be forwarded to the County Surveyor at the underwritten address on or before 28th day of June, 1923.

T. W. WEEDING,
Clerk of the Council.
County Hall,
Kingston-upon-Thames,
14th June, 1923. A 83

Draughtsman, thoroughly experienced in the design of reinforced Concrete Buildings, Coal Bunkers, etc., WANTED by an Engineering Firm in South Yorkshire. State age, salary and experience.—Address, A 878, Offices of ENGINEERING.

Draughtsmen, Senior and Junior, REQUIRED, with knowledge of motor car and engine design.—Address, A 88 Offices of ENGINEERING.

Wanted Immediately, capable DRAUGHTSMAN with experience in up-to-date steam turbine design. State previous experience and age, and also salary expected.—Address, A 864, Offices of ENGINEERING.

Wanted for a Well-known Firm of Engineers, a DRAUGHTSMAN with experience in high lift turbine centrifugal pumps. Applicants to give full particulars of previous experience, and to state age and salary expected.—Address, A, 865, Offices of ENGINEERING.

Wanted, an Assistant TURBINE DESIGNER to assist Chief Engineer of well-known Steam Turbine Builders. Previous experience on "Impulse" Turbines essential, and must be qualified trained man. State age, previous experience and salary required.—Address, A 863, Offices of ENGINEERING.

Reinforced Concrete Designer WANTED, accustomed to Design and Detailing. Must be experienced. Send full particulars.—Address, A 874, Offices of ENGINEERING.

Constructional Steel DRAUGHTSMAN.—Wanted in London Draughtsman for design and detail of construction steelwork under the London Building Acts and the L.C.C. (General Powers) Act 1909, for steel-framed buildings. London experience preferred.—Address, stating age and salary, A 891, Offices of ENGINEERING.

Draughtsmen Wanted Required for Steel Caissons, Dock Gates and Heavy Opening Bridges. Only men who have actually been recently engaged upon the designing detail drawings of such work need apply.

Applications, stating age, salary required and full particulars of training and experience, and when at liberty, to STAFF MANAGER, PORT OF LONDON AUTHORITY, Trinity Square, E.C. 3. A

Draughtsman Required with good experience in Locomotive, Carriage and Wagon Work, and Internal Combustion Engines.

Apply, stating age and qualifications to the SECRETARY,
Office of the
HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA,
Trafalgar Square, W.C.2.

Chief Draughtsman Required by prominent firm in the Midlands, manufacturing electrical equipment, including magneto lighting and starting sets, for automobiles. Applicants must have had first-class experience, intimate knowledge of the quantity production of small electrical machinery, and should preferably have already held similar positions with firms of good standing. If required, accommodation may be found.—Applications, which will be treated confidential, should be addressed, stating age, qualifications, details of experience, and salary required, A 898, Offices of ENGINEERING.

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A 752

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THE FUEL RESEARCH BOARD.

II.—STEAMING IN VERTICAL RETORTS.

(*Continued from page* 736.)

COLLATION AND EXPRESSION OF RESULTS.

THE leading results of each test, including its weight balance, were collected in a main table, which was supplemented by subsidiary tables, giving details of temperatures and pressures, analyses, and weight balances. These quantities were given for the whole test, and again were calculated variously per hour and per ton of coal and per cent. as seemed most useful; but some further less obvious inferences were made, largely with a view to comparisons with other tests.

Heat Spent on Carbonisation.—When coal is being carbonised the retort setting is at the same temperature as it was during the determination of the heat spent on the setting, and therefore loses the same quantity of heat by radiation, conduction and convection. The volume and temperature of the flue gases, however, and the temperature of the preheater setting are different from what they were during that determination, and if allowance is made for the difference in these losses a closer approximation is obtained to the true value of the heat spent on carbonisation. To determine this value the heat spent on the setting as determined by the run on coke is divided into the constant quantity spent on radiation, conduction and convection from the setting proper (with which for convenience is included the heat produced by the combustion of coke in the retorts, though strictly a part of this quantity, by no means constant, is lost in the flue gases) and the variable quantities lost in the flue gases and by radiation, conduction and convection from the preheater. The heat carried off as sensible heat by the flue gases is calculated from their temperature and composition and the quantity and composition of the fuel gas, and the difference between this and the total heat supplied to the setting is taken to be the total losses due to radiation, conduction and convection. To separate these into the constant loss from the setting proper and the variable loss from the preheater the temperatures of the flue gas are taken on leaving the retort and the preheater, and of the air on entering the setting after passing through the preheater. The heat lost by radiation, conduction and convection from the preheater will then be equal to the difference between the heat carried to it from the retorts by the flue gases and the heat carried from it by the air that passed through it to the retort setting. The constant loss by radiation, conduction and convection from the setting proper is then obtained by deducting the sum of the flue gas and preheater losses from the total heat supplied. For the station setting it was found to be 8·37 therms per hour at the carbonising temperature, 1,266 deg. C.

The heat spent per hour on carbonisation in each test can then be obtained by deducting from the heat supplied per hour in water gas and steam the total of the heat carried off per hour by the flue gases and dissipated from the preheater setting in the test in question and the 8·37 therms per hour spent in every test on radiation, conduction and convection from the retort setting proper. This difference, expressed as therms per ton of coal carbonised, is a measure of the heat spent on carbonisation, or expressed as a percentage of the total heat added may be regarded as a measure of the efficiency of the carbonisation in the plant and under the conditions in question. This efficiency, however, is not to be confused with the thermal economy of the process, not only because it takes no account of the thermal value of the resulting gas, coke and tar, but also because it depends on the magnitude of the constant loss as well as on the thermal economy of the carbonisation process itself.

Yields and Costs of Products with and without Steaming.—The heat supplied per hour in each test is calculated from the heat of the fuel gas used and the steam, if any, supplied; from this total the heat spent on the settings—the 12·4 therms per hour for carbonisation at 1,266 deg. C.—is deducted, and the difference, which is the net heat supplied per hour for carbonisation, is calculated for each test in therms per ton of coal carbonised. As against this net supply of heat the products are set, which may be expressed as heat value of the gas produced in therms per ton of coal carbonised, or alternatively as calorific value and volume of the gas, in addition to the amounts of coke, tar and sulphate of ammonia.

The yields of these products appeared to vary with the percentage of steam regularly enough to allow of their being exhibited usefully in graphs, showing the quantities and thermal cost of the gas and other products made at each steam percentage. These particulars are exhibited in three graphs for each coal examined. On each graph the values in therms of the gas made per ton of coal carbonised with each percentage of steam are set off as abscissæ, the percentages being indicated by vertical lines. On one graph the ordinates are the therms of fuel gas and steam supplied for carbonisation per ton of coal carbonised, plotted separately for gas, steam, and both together. These figures are obtained by subtracting the 12·4 therms spent per hour on the setting from the total heat supplied per hour in fuel gas and steam, calculating the difference to therms per ton of coal carbonised, and dividing this figure between fuel gas and steam in proportion to the amounts of heat supplied in them respectively. Another graph has three curves with ordinates on separate scales, representing the yields of coke, tar and sulphate of ammonia per ton of coal carbonised, and where notable differences occurred a fourth curve was drawn showing the amount of breeze included in the coke. The third graph has corresponding curves for the volume and calorific value of the gas made.

The value of these graphs for use in other works lies in the fact that in any setting of the same type of retort as was used at the station the same amounts of heat and steam applied to the same coal at the same carbonising temperature will give approximately the same yields of products. If, therefore, the figure for the heat spent per hour on another setting, determined either by a run on coke or by calculation as described above, is calculated on its throughput to a figure of therms per ton of coal carbonised, the ordinates of the first graph (corrected if necessary for change of fuel gas as described above) added to that figure shows the total heat that must be supplied to the setting in order to obtain, for the percentage of steam in question, about the same amounts of the several products from the same coal carbonised at the temperature used by the station. By then putting in on the one hand the economic costs of heat conveyed respectively by fuel gas and by steam, and on the other hand the local prices of gas, coke, tar and sulphate, it will thus be possible to estimate at once the optimum percentage of steaming for the particular coal in the setting in question, and to assign approximately the quantities of products that will be obtained.

Heat Cost of Gas Gained by Steaming.—Another convenient method of exhibiting the results is to construct a curve showing not the economic but the purely thermal cost of the heat gained in the make of gas from a given coal, when steamed at various percentages, over the heat obtained in the gas produced by carbonising without steam. In such diagrams the abscissæ represent in therms per ton of coal carbonised the additional heat contained in the make of gas (that is, its volume multiplied by its calorific value) with various percentages of steaming over what is obtained from the coal without any steam, and the ordinates represent the heat, also in therms per ton of coal carbonised, supplied at the several percentages of steam by fuel gas, steam and combustion of coke within the retorts respectively in excess of what was supplied when carbonising without steam. The ordinates for fuel gas, steam and coke consumed are set up successively on top of each other, so that the topmost curves are plotted from their sums and represent the gross thermal cost of producing the additional gas. The amount of heat in the additional tar is set back from this curve to give a curve of net thermal cost, the thermal effect of the extra ammonia being neglected. The significance of these curves is, of course, limited to their thermal meaning, the economic costs having to be calculated as indicated in the previous paragraph.

Similar constructions may be used to exhibit the quantity and calorific value of the enriched water gas that would be needed to take the place thermally of the additional gas produced from a given coal by various percentages of steaming. Against the same abscissæ as are used in constructing the curves of heat cost of the additional gas gained in steaming, ordinates are first set up to represent respectively the volume and the calorific value of the additional gas, which will, of course, be the same as those of the enriched gas to be substituted. From the curves so drawn ordinates can be taken off to represent respectively the total heat in therms of the additional gas and the heat in the same volumes of water gas, the difference between them representing the heat to be added by enriching the water gas in whatever way may be most economical and convenient. Finally, against the same abscissæ ordinates can be set off successively to represent the heat in the steam and the coke needed for producing the required volumes of standard water gas and in the enrichment that has to be added. The topmost curve thus represents in therms per ton of coal carbonised the total heat spent in the water-gas generator to produce for various percentages of steaming the same amount of heat in the additional gas as is obtained from the retorts by the steaming; and by superposing the curve of net thermal cost obtained with the same abscissæ as described in the last paragraph the relative thermal economy of the steamed retorts can be compared with that of the equivalent enriched water gas.

(*To be continued.*)

THE PROVAN CHEMICAL WORKS OF THE GLASGOW CORPORATION.

UNTIL a few years ago the production of coal gas followed the lines of the original process of Murdock, in which long horizontal retorts were used for the carbonisation of the coal. In many respects during succeeding years the details of the plant used were improved to obtain greater efficiency of working, and the magnitude of the operations in any particular station was increased to meet the growing industrial and domestic demands. The plant was almost entirely run in those days for the production of gas, and very small consideration was given to the extremely valuable by-products obtainable during the working of the process. With new conditions of demand for these materials during the European War the gas works of the country became the sources of derivatives of the highest value, and the changes in methods of working that followed had as their object the increased production of the secondary products.

Vertical retorts have now replaced the horizontal ones in many works and are being installed in increasing numbers. This change was adopted because of the advantages possessed by the new system in the winning of by-products. In retorts of the horizontal type there is a large free space above the fuel bed, and this has many disadvantages which are not existent when vertical retorts are used. Greater yields of gas from any quantity of fuel are obtained with the vertical type of retorts, due to the differing temperature conditions prevailing in the two cases. The new system has also a substantial claim to recognition because the gas is taken away from the top, which is the least heated portion of the retort. In consequence of this the tar produced is much more fluid than that obtained from horizontal retorts. Other important effects are that naphthalene is largely removed from the gas by the ordinary processes of condensation, without special treatment, and the yields of tar constituents of low boiling-points are increased. Ammonia is obtainable in greater quantities when vertical retorts are used, and the coke resulting from the carbonisation is harder and denser than that produced from the same fuel in horizontal retorts.

The Glasgow Corporation have four gas works in different parts of the city, of which the largest and most important is that at Provan. Until a few years ago the corporation leased the by-product works at each of their gas works to firms who contracted for the purchase of the liquors and tar. That arrangement was recently brought to an end and the corporation founded a chemical department of their own, run as a separate organisation from the gas department, and put under the charge of

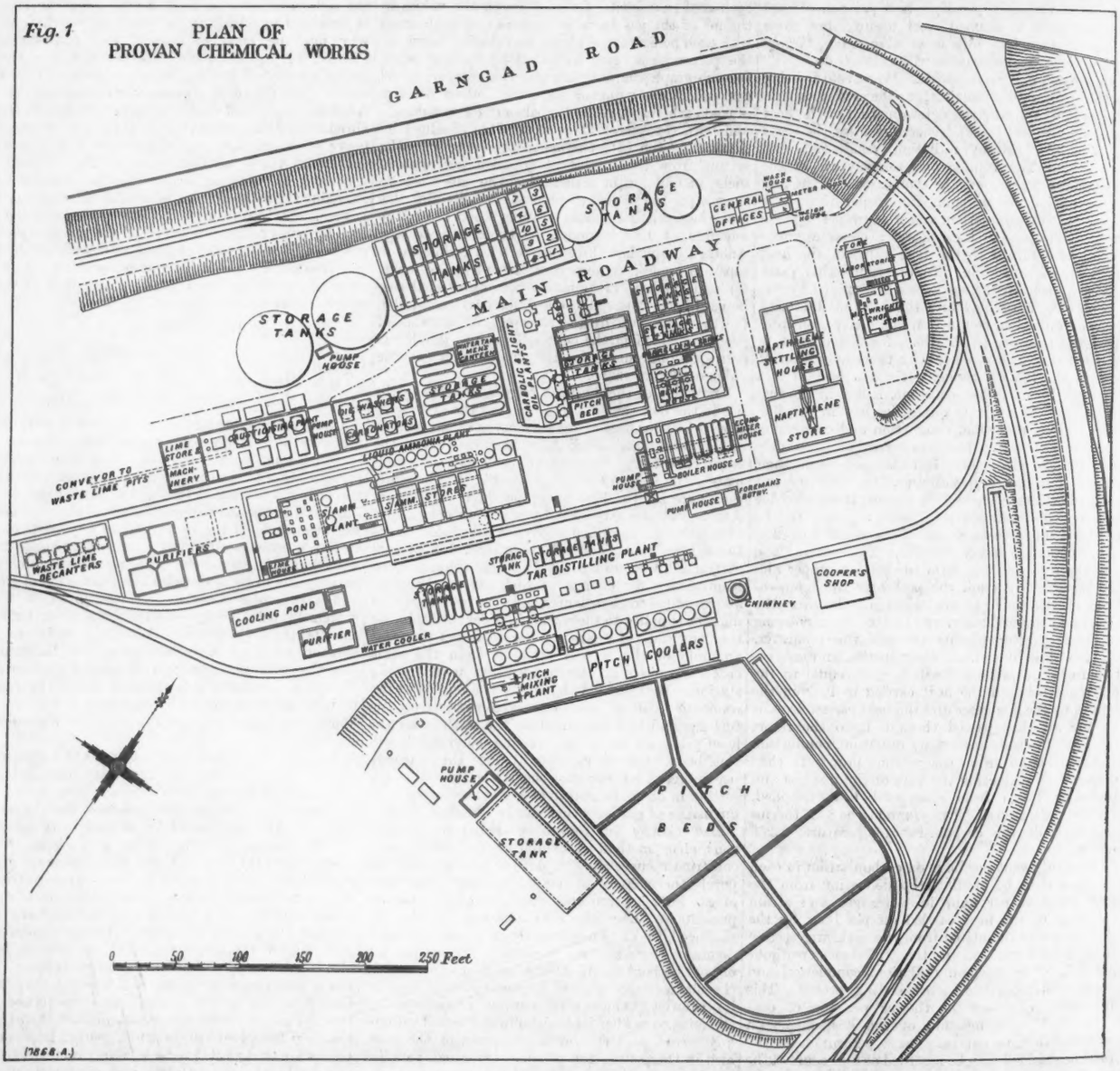
Mr. W. A. Walmsley, B.Sc. Since then there have been great development, and the works at Provan have been enormously extended. At all four works the simple operations of tar distilling and extraction of sulphate of ammonia are continued, but new plant has been installed at Provan where all the operations connected with the refining of the crude materials are concentrated. The works rank as one of the most completely equipped for the recovery of by-products and derivatives and their purification, which have been put down in this country.

too far west to be shown in the plan. The various sections of the works have been put down in positions to obtain a straight flow of the materials in the processes of production and refining. Finished products follow a course to one side of the works and waste materials to the other.

The works may be considered as comprising three sections, sulphate of ammonia, tar distilling and the production and separation of the valuable derivatives from the tar. The sulphate of ammonia plant occupies a position between the other two. The boilers is 10,000 lb. per hour, and all the steam produced is superheated. An ash hoist raises the ashes from the pit below the boilers to an elevated hopper to facilitate loading into trucks on the railway.

The lay-out of the ammonia plant is illustrated in plans, elevations and sections on Plate XLVI. The plant was designed by the manager of the department, Mr. W. A. Walmsley, with the collaboration of Messrs. Ernest Scott and Co., Limited, who carried out all the erection work. It consists of two independent units, each of suitable capacity to deal

Fig. 1 PLAN OF PROVAN CHEMICAL WORKS



In the gas works the horizontal retorts, which were erected in 1904, have now been completely replaced by vertical ones of the Woodhall-Duckham type. There is also a water-gas installation available as a reserve. The total capacity of the plant amounts to 45,000,000 cub. ft. and the yield of gas per ton of fuel is about 12,000 cub. ft. of a calorific value of about 500 B.Th.U. per cubic foot.

The lay-out of the Provan Chemical Works is shown in the plan, Fig. 1. Railway lines are run round three sides of the works, and branch lines serve for the feeding of the tar stills and the removal of pitch, for the delivery of ammonia liquors and the despatch of ammonium sulphate and the products derived from the tar. There are branch lines through the works to facilitate operations, and these are brought together and join the main line at a point lime and ammonia liquors are taken in at the one end of the works and the sulphuric acid is stored beside the plant where the sulphate is produced. The finished product after drying is bagged and despatched from the other end of the works. The tar is conveyed to the stills where the tar oils are driven off and the various fractions separated and conveyed to the one side, while the pitch is passed to coolers and pitch beds on the other. The tar oils are first passed to storage tanks, and from there conveyed to the washing plant in the refining section and on to the carbolic, naphtha, light oils and benzol plants. Storage accommodation is provided for all products, and suitable arrangements made for easy loading on road or rail. The boiler-house equipment consists of Babcock and Wilcox water-tube boilers fitted with Underfeed stokers. The evaporative capacity of each with 70,000 gallons of 1 per cent. crude ammonia liquor per day. The liquor is taken to four large cylindrical vessels situated outside the general buildings. From these it is conveyed across the pump house to the stills in the next section. The ammonia is driven off into the saturators where it combines with sulphuric acid, and the product is deposited on to the draining table from which it is lifted by scraper conveyors and conveyed to the hydro-extracting and drying plants in the bays of the next section. All the pumps are concentrated in the one house, and in the building beside it are the lime mixers for the preparation of the solution for the stills while the sulphuric acid tanks, large egg-ended cylinders, are mounted in line with them, but at a higher level. The power for driving the pumps is obtained from small steam engines driving a line of

SULPHATE OF AMMONIA DRYING PLANT AT THE PROVAN CHEMICAL WORKS.

Fig. 8. ELEVATION.

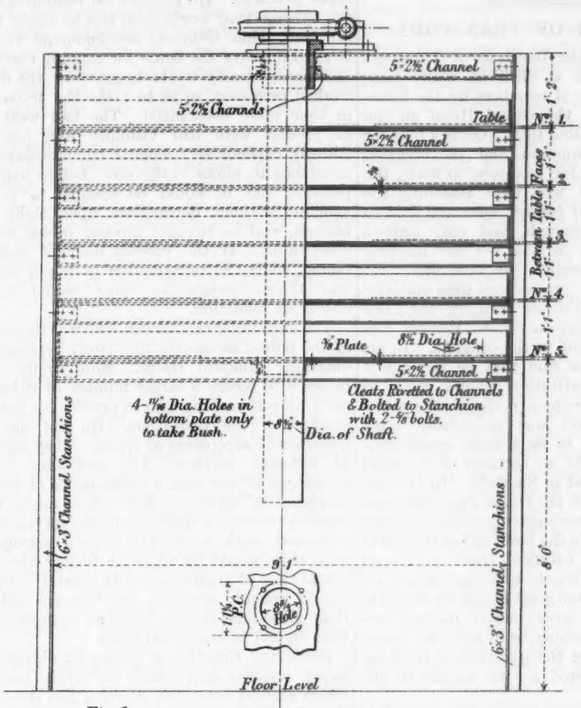


Fig. 9. PLAN.

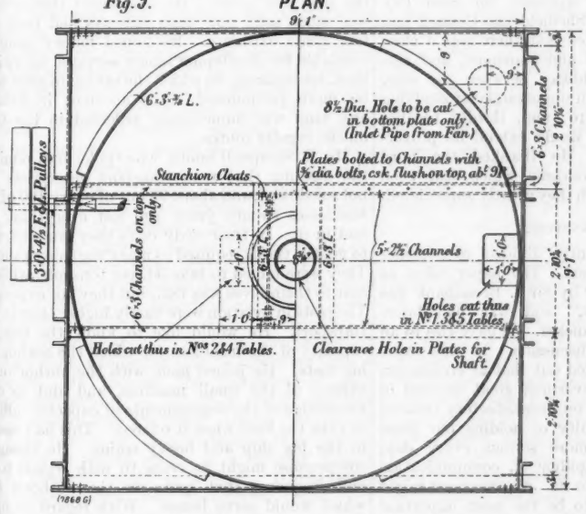

9-1
6-3 Channels
6-3-⅜ L.
8½ Dia. Hole to be cut in bottom plate only (Inlet Pipe from Fan)
Plates bolted to Channels with ⅞ dia. bolts, csk. flush on top, abt 9
Stanchion Cleats
3-0-4½ Ext. Pulleys
6-3 Channels on top only
5-2½ Channels
Holes cut thus in Nos 244 Tables.
Clearance Hole in Plates for Shaft.
Holes cut thus in Nos 1, 345 Tables.

Fig. 15.

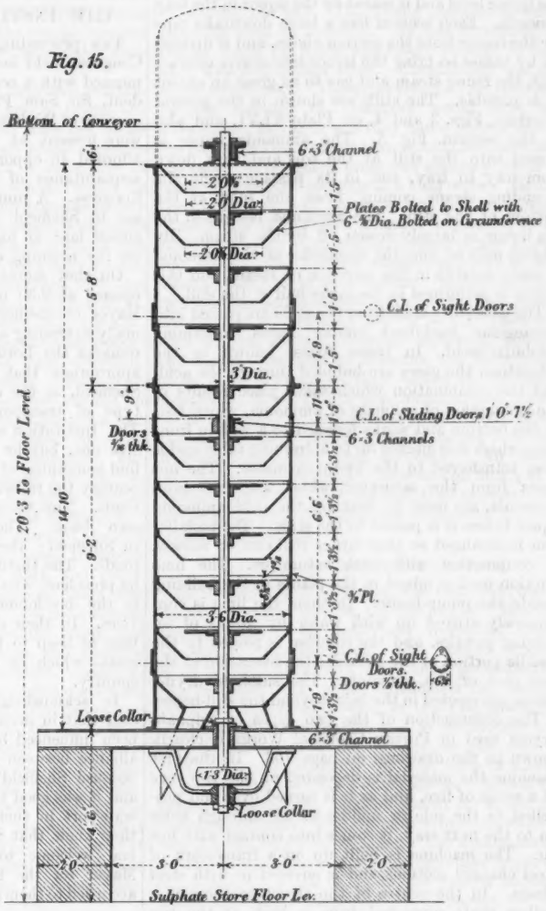


Fig. 16.

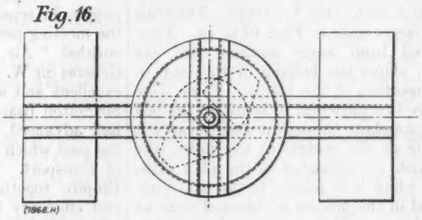


Fig. 10.

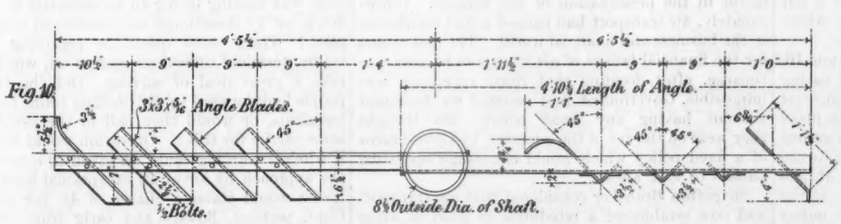


Fig. 11.

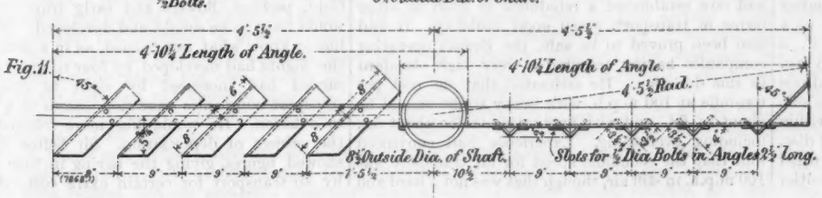


Fig. 12.

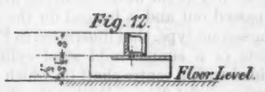


Fig. 13.

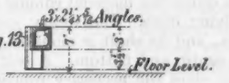
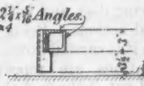


Fig. 14.



shafting. Motion is also taken from this shafting to the revolving system of the lime mixers.

Each still is built up of 15 cast-iron sections of 7 ft. diameter, the total height being 24 ft. There are three gas passages in each section covered by mild steel serrated hoods, and an overflow pipe maintains the liquor level and is sealed by the liquor in the tray beneath. Each section has a large downtake pipe for the liquor from the section above, and is divided up by baffles to bring the liquor into active contact with the rising steam and gas to as great an extent as is possible. The stills are shown in the general drawings, Figs. 3 and 4, on Plate XLVI, and also in the section, Fig. 5. The ammonia liquor is passed into the still at the top and runs down from tray to tray, and in its passage meets the ascending steam coming from the inlet at the bottom of the still. The ammonia present in the gas liquor is largely driven off by the steam. By adding milk of lime the remainder of the ammonia is made volatile in the presence of steam, and this action is performed in the lower half of the still.

The gases driven off from the stills are passed into rectangular lead-lined timber boxes containing sulphuric acid. In these boxes, known as the saturators, the gases are bubbled through the acid, and the combination which takes place results in the production of sulphate of ammonia, which falls to the bottom and works forward to a well in front from which it is ejected on to a draining table and is later transferred to the hydro-extractor. The hot gases from the saturator, which are free from ammonia, are used to heat up the cold ammonia liquor before it is passed to the stills. The installation is arranged so that either still can be worked in conjunction with both saturators. The lime solution used is mixed in the plants in the building beside the pump-house. In them the lime is continuously stirred up with water by means of revolving paddles, and the solution is passed to the middle portion of the stills for the liberation of the last part of the ammonia. The sulphate drying plants are erected in the bays beyond the still-house.

The construction of the two types of sulphate dryers used in Provan Chemical Works is clearly shown in the drawings on page 763. In the first machine the material is deposited on the top tray of a series of five, and as it is turned over and propelled to the side or middle to fall through holes on to the next tray, it comes into contact with hot air. The machine is built up on a framework of steel channel sections and is covered in with steel plates. In the centre of the structure there is a hollow shaft supported from a bush at the top which is mounted on the top framework. The shaft is driven by worm gearing and carries two arms, one on each side, within each of the five trays. The arms are shown to a larger scale in Figs. 10 to 14. They were constructed from angle sections and are mounted 3½ in. above the bottom of the tray to permit of the insertion of the blades. These were designed to serve two purposes, to break up the bed of material by ploughing through it and to carry it over to the side or the middle to the holes (the positions of which are indicated in the plan view, Fig. 9) through which it is passed to the next tray. The hot air used in the process is obtained from an adjacent coke furnace and is blown through the dryer by a Sirocco fan. It carries away with it the moisture from the sulphate, and the product is left perfectly dry at the outlet from the fifth tray, where it is passed out and is bagged for the market.

The second type, that illustrated in Figs. 15 and 16, consists of a simple mild steel cylindrical casing provided with a centre shaft on which are connected a number of flat discs. Within the shell of the plant a number of pressed cones are bolted in such positions as to direct the material coming upon them to the revolving discs. The rotary system runs at 300 r.p.m., and its shaft is mounted in bearings at the top, centre and bottom. A belt drive to a pulley below gives the necessary rotation. Hot air at a temperature between 150 deg. and 200 deg. C. is blown in at the foot of the dryer by a Sirocco fan. The moist sulphate is charged in at the top and drops on the first revolving disc, and is thrown to the side by the centrifugal actions. Being gathered within the inverted cone it is carried down to the next disc, where the operations are repeated. The dried sulphate is passed out at the foot through two outlet chutes. This type of dryer does not afford the same flexibility for charging large quantities of the moist sulphate as is given by the dryer first described.

(To be continued.)

THE INSTITUTE OF TRANSPORT.

THE proceedings of the Institute of Transport Congress, held last week at Sheffield, really commenced with a reception of members by the President, Sir Sam Fay, at the Grand Hotel on the evening of Wednesday, June 13th. Quite a number were present at this junction, and the occasion afforded an opportunity for members to make the acquaintance of others who were attending the Congress. A number, of course, were not able to get to Sheffield early enough, and only arrived either late at night or in time for the meeting on the morning of Thursday, the 14th inst.

On that morning the proceedings were officially opened at 9.30 in the Cutlers' Hall, by the Lord Mayor of Sheffield, Alderman W. C. Fenton, formally extending a welcome to the congress. In his remarks the Lord Mayor said that he thought it appropriate that the Institution should come to Sheffield, as the city provided materials for every type of transport. Steel was universally used. The Institution seemed to be a most comprehensive one, but he thought all sections of it would find something of interest in Sheffield. In the last century the railways took the traffic away from the roads. Now the latter were getting a little of their own back. They made the best rails in the world in Sheffield; they had excellent trams and good roads. The Institution was to be congratulated on its president, who had done great things for Sheffield in the development of cross-country railway services. In their deliberations he would like members to keep to the fore the question of reducing costs—which he considered a vital matter to the country.

In acknowledging the welcome, Sir Sam Fay said that in deciding on Sheffield the Council had been influenced by the fact that there was a close alliance between Sheffield and transport, and also because Sheffield was midway between the seas, and it was good to have an opportunity of studying transport in such a centre; and, thirdly, because they knew that Sheffield would extend its proverbial welcome to them. He thanked the Lord Mayor for the hearty welcome which had been accorded to them and which they greatly appreciated.

AIR TRANSPORT.

The meeting subsequently divided to consider papers on separate subjects. The paper taken at the meeting presided over by Sir J. Broodbank was entitled "Air Transport," and was by Major-General Sir W. Sefton Brancker. It gave rise to an excellent and sustained discussion. In this paper Sir Sefton Brancker pointed out that as civilisation had advanced, disaster overtook great empires of the past which had relied on unsatisfactory systems of transport. The difficulty of holding our great Empire together grew more serious every day, and efficiency in, and rapidity of, communication offered the only solution to it. Air transport might well prove, he thought, to be the most important factor in the preservation of the Empire. Unfortunately, air transport had earned a bad reputation in the business and financial world. The real reason for the financial failure of air transport to date was because, after deciding that State enterprise was impossible, Government had assisted air transport without having any fixed policy. He thought they were on the eve of the adoption by Government of a fixed policy which would encourage operating parties to look ahead.

Sir Sefton Brancker considered that air transport had now established a reliability as good as other forms of transport, given good visibility. It had also been proved to be safe, the British operating companies having acquired a very high standard in this direction. He estimated that the cost per ton-mile at 100 m.p.h. with heavy traffic should be about 3s. 6d., and with fluctuating traffic about 5s., including everything. Experience had convinced him that the economic speed for air transport was 100 m.p.h. in still air, though that was not a hard and fast rule. Assuming as an average half a full load, five passengers could be carried for 5s. per mile, or 1s. per mile each. With heavy traffic that could be reduced to about 8½d., but he did not think passengers would pay more than 6d. per mile for rapid journeys. He thought on established routes the average load would soon rise to above the half full load, while technical developments would also tend to improve the figure for running costs. Mail and parcels traffic would improve as the distances worked increased, so as to make the actual saving in time more substantial. The two weak points at present were bad visibility and high costs. Already dependable telephone communication gave assistance to pilots in the air. Before long it was possible that it would be feasible to control a machine without dependence upon sight of the horizon, and he thought landing in fog would be practicable. At the present moment costs were falling, while the introduction of heavy oil, which was almost certain to come, would make an enormous reduction.

The most important factor of all was the education of the public, as success ultimately depended upon obtaining sufficient traffic. More would have to be done to secure a larger number of flying hours per year per machine, and to provide for the greater comfort of the passengers. He did not regard airships and aeroplanes as rivals. They were suited to different services. The aeroplane had the advantage of low cost, a consequence of which was frequency of service, a fact which might make it possible to work a daily aeroplane service to India compared with a weekly airship service. The advantage would be with the former though the actual time of transit might be greater. An airship should, roughly speaking, not be employed on less than 1,000-mile stages, while an aeroplane's stage limit should be about 300 miles.

Sir Sefton Brancker in giving an abstract of his paper, referred particularly to tables and charts, which showed how civil aviation had developed in the past four years. He considered that aviation was much safer now than railways had been after four years existence. He hoped money would be available for developing longer services, to Switzerland, for instance, on which the saving in time would be more pronounced. Any accident in flying of any kind was immediately reflected in the traffic on the regular routes.

Mr. E. Shrapnell Smith, who spoke first, reminded the meeting that road transport enterprises were not subsidised, and about 99 out of every 100 of such businesses twenty years ago lost everything they had in it. In their early days they were expected to get the traffic required to make the thing a success. They were forced to take 3d. per ton-mile, while the cost to themselves was 18*d.*, but they got experience. The costs in aviation were vastly higher than in road transport. He would like to know the dead lift capacity of the machines for which the author gave his costs. He joined issue with the author on the subject of the small machine, and did so on a knowledge of the requirements of capacity sufficient to take the load when it offered. This had resulted in the big ship and heavy trains. He thought a compromise might be come to with regard to size and frequency (not quite on the author's lines) which would serve better. With regard to operation, was landing in fog to be achieved by slowing down, or by directional and locational aids to the pilot? There were questions regarding pick-up traffic, terminal difficulties and so on, which would take a great deal of solving. Did the transport people look forward to distributing traffic from their terminals, or would they call in the assistance of some carrier for this? Operation would be assisted if wireless warning could be given to a terminal of the approach by air of an exceptional load. What traffic would stand a charge of 4*s.* per ton-mile? Gold, perhaps, flowers and early fruit, but these would have to be sought and developed. He would like to know what *was* carried, as in a period when the flights had developed by four to one, the loads carried had increased by eight to one. Road transport companies were not jealous of a subsidy to aviation. He would like more information on the subject of depreciation. Sir Sefton Brancker showed figures, giving the saving in time effected by air transport for certain extra cost over other

systems of transport. If these were worked out the saving was at the rate, in some cases, of 11*d.* per hour, so that it would seem that air transport would be economical even in the case of common labour.

Mr. H. Mattinson said traffic was elusive and had to be sought. All transport concerns had to exercise patience and a persistent pursuit of their object in their early years. Air transport would succeed but it would be after years of difficulties. The traffic habit was very important and had to be developed. As yet, air transport was only four years old and it was foolish to expect too much of it. The Manchester Ship Canal had only just begun to pay. Any subsidy granted should be for service rendered. Reliability must be developed, and it was useless gaining minutes on a journey if hours were to be lost at the ends of it.

Mr. Selway contributed to the discussion, his opinion being that there was no real need in this country for passenger or freight air services and such were not likely to come unless there were radical changes in the matter of costs. He did not think subsidies were required here in view of the services given by the older forms of transport.

Mr. E. C. Cox said the question of State assistance was debatable. Why should air transport be subsidised to put it into a position to compete with all other systems? In their early days railways had been actually hampered in their development, and railways would oppose subsidies for aviation. To be a commercial proposition, night flying for mails and papers was essential.

Mr. A. Neal said if air transport were considered from the passenger point of view, safety was a first consideration. Nothing could be more reassuring than the figures the author gave in that connection. It was not fair on the commercial side to compare air transport with the older established system. It could not be compared with road transport. It had its own peculiar advantages. The size of unit surely depended upon the load factor. If you started with small units well filled, afterwards it was possible to pass to the larger unit, when that would prove the more economical. He thought it right that civil aviation should not be divorced from the military side and put under the Ministry of Transport. The developments were bound to have a beneficial effect on military aviation. Whatever form assistance took it should be spread over a long period, and pioneers ought to know for how long they could rely on such help, or no definite developments would follow. The amount granted should vary according to the service given.

Mr. A. E. L. Chorlton said certain critics did not seem to appreciate the enormous speed with which aviation was developing. The costs of operation were very high as yet, the upkeep of mechanical power representing some 60 per cent. of the running charges. Petrol represented about 23 per cent. The proportion of 60 per cent. was higher than in any other form of transport. He thought the possibility of using cheaper fuel attractive, but they should not look to that immediately for relief. Crude oil certainly was from five to six times cheaper than present fuels, and it would result in a simpler engine, which, however, would be heavier. When, say, a three hours' flight was considered, could they afford to pay for a 50 per cent. heavier engine? The gain was not quite so attractive as it appeared on the surface. He thought they ought to tackle the engine of to-day, and simplify it. So far the engine had not been separated out in statistics, so that they could gather where improvement might be sought. The average weight now was about 2 lb. per h.p.—would 3 lb. per h.p. give better results? Would the reliability thus secured compensate for the additional fare lost? From the commercial point of view, reliability of service was very important. He thought the subsidy was really paid from the point of view of national defence. Many people were not interested in aviation except from that point, and he therefore considered that they needed services within our own borders proceeding all the time and not liable to interruption by outside politics, so that defence would benefit to the greatest extent by experience.

Mr. W. H. Gaunt said he had looked into the question of aviation with a view to distributing food products from centres, but the prospects were not promising at present at home. If samples of tea from India were brought by aeroplane ahead of the main shipments they would not be representative, as they would be subjected to very different conditions on the way. Development depended largely upon the standing the services had with the public. Something might be done to familiarise people with the passage of machines of the regular services so that it might be realised how dependable they were becoming.

Mr. F. Handley Page remarked that civil aviation was really the only means they had of trying out war machines in peace. The men were out in all conditions of weather and with all kinds of loads. So far they had suffered from lack of continuity of policy, but he hoped security of tenure would be guaranteed. Without it it was not possible to buy machines, train men, or lay out terminals. Compared with the work performed the French actually got more flying for the subsidy they paid than we did. With regard to research, it was important that this should be followed up in connection with machines. Small machines were more efficient, h.p. for h.p., than large. He thought there might be an opportunity of cutting down costs in this direction. Distributing agencies were already working in connection with Croydon. Air-sickness was not so serious. In all his experience, though himself a bad sailor, he had only seen one person ill. The remoteness of aerodromes was a difficulty, but even if an area were available inside London, he did not think the public would yet allow regular flying into and out of the centre of the Metropolis.

Col. F. Searle said he had been through the mill with other forms of transport. Road transport had met similar troubles at the start, and many people had burnt their fingers because there was no one to give the pioneer advice. On the question of depreciation, he knew of a machine which had flown 120,000 miles, in which time the fuselage required no attention or replacement whatever. Prospects were not so black. The engine costs were high, and flying hours low, about 150 hours per annum. When they had done 25,000 miles they were ready to come out. Engine maintenance cost about £3 10s. per hour for valves, gudgeon pins, big ends, etc. These were the main troubles, and if they could be overcome costs would rapidly come down. Better use of the machines would reduce costs and overhead charges. At present insurance was trying to kill the industry, and it was essential that they should get the insurance companies into a more favourable attitude.

Before calling upon the author to reply to the discussion, Sir J. Broodbank remarked that in the scheme now suggested the subsidy would be paid in unequal instalments and that provision was made for operational research.

Sir Sefton Brancker, in reply, said the rectitude of building up a rival to other forms of transport was open to question, but the position of air transport was unique. It had been created by the war; other systems had been built up on commercial lines. Air transport had to be converted from one to the other. It was also of military value and the regular services had already taught a great deal which was not brought to light in the war. The proposed scheme would enable the early years to be tided over when costs were high and revenue poor. His figures had been worked out for the D.H. 34 machine, taking 2,000 lb. useful load with 450 h.p. His proposal of 10 services a day might be exaggerated—five might answer with machines of double the size. The only disadvantage of the small unit was that the staff had to be larger. The chief thing to solve was landing in a fog. Possibly leader wires would assist in this. With stable machines there would soon be no difficulty in getting off in fogs if they knew the weather to be fine outside. The ideal means of communication with the Croydon Aerodrome would, he thought, be by tube railway with frequent service. They were to-day discouraging the use of wireless for informing terminals regarding the character of loads, as they were fully occupied in organising details of operation.

British newspapers by air transport got to Paris early enough to be distributed to European Capitals beyond at the same time as French. That was very important. The traffic available now consisted of small articles of value, bonds, samples, &c., and ladies' clothes which went out of fashion in a week or two. Pilfering was practically eliminated in air transport and insurance was therefore cheaper. Air transport would come midway between wireless and train services. Night flying was possible to-day and a great deal of it had been done, but not heard of, during the war. The young generation would grow up used to aviation. He was convinced an engine could be made absolutely reliable so long as it was well looked after. Unreliability was due solely to the war. The supervision of air transport by the Ministry of Transport would have had advantages, but as it was they had a greater call on the Research Department than would then have been the case. With small units the capacity could be better adjusted on sections of a long route. He had been told that with kerosene fuel and an increase of weight of 12 per cent. it would be possible to get 1,200 hours out of an engine instead of the present 200 hours. The heavier engine was not a very serious hindrance to development. Ground organisation was essential and unfortunately for any general distributing scheme that had to be very elaborate, with wireless station, weather reporting, lighting, and so on. In spite of subsidies the French had made little progress as they lacked the necessary incentive. Motor gliders were handicapped, as they could not contend economically with head winds. The higher speed machine made better headway, of course, and was more airworthy. Air was a perfect medium for flying; there was no dust and no shocks. Once off the ground the machine was perfectly happy. Taxying was responsible for most of the wear and tear.

Railways in Industrial Centres.

On the morning of Thursday, the 14th inst., one of the papers taken was on the subject of "Railway Requirements of an Important Industrial Area," by Mr. J. A. Jenkinson. The subject proved to be so wide that little more than generalisation was possible. The paper considered the subject from two standpoints, viz., in the first place the requirements of the public, and in the second how such requirements could be met by the railway companies. In discussing the best form of service it was pointed out that a quick service afforded the greatest satisfaction. In the search for speed the expenses of actual operation were reduced and heavy expenditure might be avoided. The amalgamated companies could now afford to undertake improvements which for lack of capital the smaller railways could not face. Passenger requirements for an industrial centre involved fast expresses to London and to provincial towns, with slower but more frequent trains in the neighbourhood of the town itself. Added to these must be excursion facilities, week-end and holiday traffic requirements, and so on. The most important duty of a railway in an industrial area was the transport of food and coal which represented roughly 2,065 wagon loads weekly per million inhabitants. This represented, of course, only a small portion of the traffic into and out of the centre. In centres of the steel and iron industry such as Sheffield much of the traffic was destined to and originated from private sidings. In other types of towns railway company accommodation had to be provided for practically all the traffic. The various services rendered by the companies were enumerated and enlarged upon, after which the author discussed the provision made by the companies for coping with these requirements, under the headings of: Permanent way and lay-out, provision of train services, operating department, and commercial department. Under the first heading the possibility of congestion was considered and the feasibility of expediting traffic by the provision of enhanced accommodation, not only in passenger and goods station facilities, but by means of sidings, concentration yards, &c. After dealing with the variety of passenger train services demanded and the wide range of traffic to be considered in goods working, the author stressed the point that running trains actually to time would at once remove very many of the difficulties encountered. Typical organisation charts of the operating and commercial departments were given, the author admitting that the subject of his paper bordered closely upon the whole question of railway services—obviously a very large subject for a short paper.

Mr. C. le M. Gosselin opened the discussion with a reference to excursion traffic. The facilities provided, the speaker suggested, savoured often more of a physical endurance test than of relaxation. He considered it would be necessary before long, by some means or other to arrive at co-ordination between the railways and road transport companies. He thought in the future the facilities afforded by road companies would enable workers and others to live further afield. The workshop might also migrate if the supply of electricity became reasonably cheap as a result of the adoption of large stations. He hoped the railways and road companies would co-operate as regards passenger traffic, while as regards goods it might pay the railways to work with the transport companies who could handle certain types of traffic more easily and economically.

Mr. J. Smith, of Sheffield, said the depots in Sheffield were very busy places, unfortunately circumscribed by roads, &c., and incapable of expansion except at great cost. The keynote of the paper was economy. To obtain better economy they would have to secure increased facilities if output was to be increased. Mechanical appliances would have to be brought up to date. Merely increasing lifting speed was of value, as they could deal with more wagons and thus handle more tonnage in the depots.

Sir Sam Fay said the railways had outgrown their clothes as far as goods stations were concerned. The only immediate solution was the provision of better mechanical appliances.

Modern Trackwork and its Importance.

The third paper taken on the 14th inst. was one by Sir Robert A. Hadfield, entitled "Modern Trackwork and its Importance." In this Sir Robert said that rails failed, in the main, either by fracture or by excessive wear. There were other possible causes of failure, but by dealing with these two, most of the metallurgical troubles in connection with rails would have been solved. Of these, at least as regards railways, the question of rail fractures was the more important because of the loss of life and feeling of insecurity to which it might give rise. Not all the disasters attributed to fracture of rails had been due actually to that cause. Still, in many cases the connection had been clear. Statistics for the United Kingdom showed 324 rail breakages in 1901, this number falling to 240 in 1914, subsequent to which after a rise it fell to 199 in 1921. In the United States there were in 1920 1,856 accidents, including 999 actual derailments, due to rails and rail joints. For 1921 these figures were respectively 976 and 566. In France it was estimated that there were 2,500 to 3,000 rail fractures per annum. These troubles had been mainly traced to unsound or segregated steel, improper physical condition, or to the development of surface cracks on the head of the rails. It had been shown in America that 90 per cent. of the rail failures in America were traceable to the ingot and the initial stages of rolling. As regards failure by wear, a small wear over a very large mileage represented actually a very large annual sum for renewals, and reduction of wear was therefore a worthy objective.

Turning to the question of modern improvements introduced to cope with this situation, Sir Robert Hadfield referred to his experiments with manganese steel in 1882, and described the early work which resulted in the introduction of this material, explaining its various characteristic qualities, and the range of work for which it has since proved suitable. Two sections of the paper were then devoted respectively one to the history of the use of "Era" manganese steel for railways, and the other to its employment on tramways. The cast material was used for crossings at points of very heavy traffic while rolled manganese steel rails were employed on stretches of line where wear was normally high, and on bad curves. Their use was discussed at the International Railway Congress at Rome last year and was generally reported upon as being satisfactory and economical. A new mill (to which reference was made in the issue of ENGINEERING of the 1st inst., page 690) recently started up by H.R.H. the Prince of Wales at the East Hecla Works was especially provided to give additional facilities for handling this quality of material.

Having briefly discussed other tough and wear-resisting alloy steels, Sir Robert passed on to the subject of sound steel and described his method of producing sound ingots. By this method the total discard could be reduced from about 43·9 per cent. to about 18·4 per cent., which meant a very material saving. With regard to the heat treatment of rails some caution was necessary because the strains produced might accentuate the tendency to fracture at unsound or segregated parts. Soundness of the rail was therefore a necessary prelude to heat treatment methods.

The principal speaker in the short discussion which followed was Dr. Desch, who said that the result obtained with manganese steel proved how important sound research work was. The special qualities of these steels had made them extremely valuable in cases in which heavy wear was encountered. Another speaker suggested with a view to reducing costs that it might be possible to arrange for a facing of manganese steel on a body of cheaper material.

American and British Road Work.

A paper which aroused considerable interest on Friday, the 15th inst., was one by Mr. A. Dryland, entitled "Some Comparisons of British and American Methods in Road Construction and Maintenance." We reprint this in abstract elsewhere in this issue. The discussion of it was opened by Mr. W. J. Hadfield, who said that, for the most part, work here consisted not so much in road construction as in the improvement of existing roads. However, they had a new circular road in progress at Sheffield largely as an unemployment scheme. In his experience in Sheffield 50 tons to 70 tons on four wheels were not unusual, while now and then they had to cope with loads of 100 tons. The roads had to be made fit to carry that traffic. They now had a quarter of a million yards of asphalt roads, made up of clinker from the destructor and Mexican bitumen. Some of them had been laid four years and showed no sign of wear. He was convinced that such asphalt was a cheaper road material than any other. It was being laid down out of the annual rates without raising loans. The improvement in our roads recently had been very great and he considered present roads almost perfect.

Mr. J. C. Haller said he was one of the unfortunates who had to deal in the country with the very heavy loads which came out of Mr. Hadfield's town. The road question was all a matter of money, and he saw no prospect of getting concrete foundation for all his main roads. The burden would be too much for the country districts. The small proportion of made roads which contented America would not do here. Engineers here would be very delighted with the absence of motor 'buses and steel tyres which Mr. Dryland remarked upon in America. Corrugation, in his opinion, was due mainly to heavy loads. If the road authorities had powers to throw any excess load off a vehicle it would be salutary—it might be a matter of 60 tons perhaps sometimes. He had tried the hard centre with water-bound material on either side, and it had served its purpose for a time. He thought too much money was being spent on improving town roads, while country roads were suffering from some neglect. Many people thought that when well laid down a road needed no attention for five or ten years, but 5 minutes was more like the actual time.

Mr. E. Shrapnell Smith said the question whether the traffic should fit the road or *vice versa* was important to cities like Sheffield, whose products were largely in heavy engineering lines. Although the difficulties of road engineers were admitted, the industry of the country was at stake, and the right of such traffic to use the roads under proper regulation was essential. He was much struck by the fact that only 10 per cent. of the mileage in America consisted of roads as we understood them. When this was taken into consideration the position of this country was unique. He did not look upon concrete as an auxiliary for foundation work with much hope, owing to the time required to set. In the United States these roads were being pushed into new country which as yet had no traffic. The steady increase in cost of concrete here was also against it. Pot holes were a disease which spread rapidly. Would it be feasible to have a flying squad to deal with these. He thought the 1922 Committee had reached some finality on the lines of speeds and weights for road vehicles and its suggestions had received general acceptance. That should be helpful both to the road as well as to the transport people.

Mr. R. Samuel said he had to do with a district which had been rapidly developed by the provision of good roads and adequate transport services. He agreed that education in highway engineering was necessary.

Mr. E. S. Rayner spoke on the matter of financing road work, stating that he thought the financial measures were behind the road methods and had not been adapted to recent changes. It was possible to get a twelve-year guarantee for a road from a contractor, but borrowing powers were insufficient to enable the cost to be spread out properly. Long term financial methods were essential.

In reply to the discussion, Mr. Dryland said it was very difficult to get subordinates to appreciate the value of the "stitch in time." They were very proud of new pieces of road, but not so proud of keeping them good. He had always paid great attention to small details in connection with repairs and found that the cost worked out at far less when this was done than it did before where roads were allowed to get bad before mending. It was pleased to hear that Mr. Shrapnell Smith thought that the latest regulations on traffic weights were more or less final. If they were, the engineers could meet the requirements. The improvement of the roads since the war was very great, and if the supply of money lasted they would ultimately have a good system. There was nothing really to prevent borrowing at present except a general reluctance which was natural in times like the present. Some public bodies did not take the advantage they might of the means possible. He regretted that the Ministry of Transport could not see its way to contribute to loan funds. Difficulties with regard to corners were really matters concerned with the acquisition of the necessary land. Powers of acquisition were restricted, and though the larger landowners generally helped them, in other cases exorbitant demands were made. Light vehicles did not trouble the engineer. It was the heavy vehicle which was the crux of the problem. During the war practically nothing had been done, yet generally speaking there was very little to complain of to-day. In view of the short time which had elapsed and the high costs he thought the progress excellent.

Tramways.

One of the two remaining papers taken at the congress meetings was by Mr. E. S. Rayner, of Hull, on the subject of "Tramways from a Traffic Point of View under Existing Conditions." In this paper Mr. Rayner developed a line of argument which aimed at proving that the tram-car was the vehicle par excellence for coping with heavy town passenger traffic. Although the author disclaimed any intention of making the paper a tirade against the motor omnibus, his remarks certainly suggested that he considered that type of vehicle quite ineffective in the matter of dealing with congested town traffic. The author admitted that it was not possible to redesign our towns, and that under the circumstances it was necessary to make the best we could of thoroughfares by speeding up the traffic, prohibiting overtaking and passing. The author's ideal was that every vehicle should be made to keep its station, and he considered that "it should not be counted a virtue that a vehicle by its mobility or the skill or recklessness of its driver should have the advantage of its speed at the expense of other legitimate road users." In connection with the use of larger tram-cars the author pointed out that it was no use providing these if small doors were retained, or the stopping time would be lengthened to such an extent, to allow of loading, and unloading that on a small headway a number of following cars would be held up. It was imperative that something should be done to prevent chaos on the roads if cheap transport was to be retained. There must be co-ordination ; it was impossible to have economical and cheap transport with an unlimited number of agencies dealing separately with the same traffic problem. There was certainly no room for unreasonable competition. There was no form of road transport that could deal with mass passenger transport as cheaply and efficiently as tramways.

Mr. Mattinson said he agreed with the points made by the author. They were, however, not opponents of the motor 'bus. Their duty was to carry everybody by the best means available, but in dealing with masses there was nothing to compare with tramways. The motor 'bus served a definite purpose, and it was the object of the Institute to reconcile the uses of different forms of transport and help to eliminate cut-throat competition. The peak load alone gave any profit, and it was not fair competition if that was to be taken from them. If that were done fares would have to be raised. Of the three classes, the private car, the 'bus or the tram, which should have priority on the road? Surely, he thought, the tram, which had the first claim on its seating capacity alone. He thought the restriction of the use of streets would come. In London it was already working voluntarily, and the slow-moving traffic kept to the side streets.

Mr. Shrapnell Smith said that everybody recognised that the tram served the community very well before the 'bus arrived, and even now no one thought tram cars obsolete. He would like to point out that measured by new route-miles since the war, tram-car systems had been extended by 100 miles, while the 'bus systems had been extended by 5,000. If traffic in certain streets was to be worked at a regulation speed we would have to have all sorts of rules drawn up. He thought at 1½ miles to 2 miles from the centre of most towns there was very little congestion. In comparing the tram and 'bus speeds of London it had to be remembered that the trams did not go into the centre of London, while the omnibuses did.

The present life of an omnibus was very different from the five to seven years given by the author. It was more like ten to twelve years, and would be more still when pneumatic tyres were more general. On one service he knew already 23 'buses fitted with such tyres were in use. With such tyres it was possible the life would be equal that of tram cars.

Although they all sympathised with tramways with regard to road maintenance it had to be remembered that the Act of 1870 which imposed that upon them, gave them at the same time certain unique rights and advantages. Costs certainly had risen, but earnings had risen, too.

Mr. A. R. Fearnley said the tramways felt at present that they were suffering an injustice. Large sums had been invested in them and they had served the population well. Speeds could not be increased without permission of the Government—municipalities were not considered fit judges of that. Chaos was arising in road transport. The tram car dealt with all the poor services such as those of the very early morning. He thought something should be done to enable a municipality to run services to points just beyond their boundaries if necessary. He thought the best test of a vehicle was the relative cost per seat provided. That showed a difference of 60 per cent. in favour of the tram car, though the figures for the 'bus were improving. Because the tram held the field they must not think they could stand still. If they did, in a few years they would find the 'bus to be getting on an equal footing. The maintenance of roads by the tramway systems was a hardship; they were maintained for all competitors.

In some supplementary remarks Mr. Shrapnell Smith said that a comparison based on seating capacity was not quite correct. That value had to be factorised by performance over the road. In Paris they had six-wheeled 'buses with 60 seats; in London they had 50 seats, and he knew that double-decked six-wheeled 'buses seating 120 had been designed. As tramways had gone to Parliament for private Bills and had accepted the responsibility of maintaining the roadway, they would have to go to Parliament for relief. He agreed that coordination was most desirable. It was a most complex problem, but unrestrained competition was of no value to anybody. With regard to the author's final claim for the tramway he would point out that in Oxford-street, London, 10,000 persons per hour were moved in one direction in the busy hours of the day, the roadway being utilised by other forms of traffic at the same time. Tramways could not perform that service. The improvement in the 'buses showed up plainly in tyre costs. Some years ago tyres cost 4*d*. per mile run. To-day that expenditure had been reduced to ½*d*. per mile.

Port Equipment.

The remaining paper considered at the meetings was entitled "Cargo Handling at Ports: British and American Methods Compared." This was by Dr. Brysson Cunningham, who first dealt with the influence which tides had on the manner in which the problems were solved. Dr. Cunningham's paper was illustrated by a number of excellent lantern slides, which were greatly appreciated. He pointed out that where tide level varied from 20 ft. to 40 ft. docks were almost a necessity, though some ports managed very well without, as, for instance, Glasgow and Southampton, where the range was below the average. In America, however, the tidal range was not serious as a rule, and there was no occasion for enclosed docks at the big Atlantic ports; berthage in such ports consisted mainly of piers and jetties. The influence of the tides extended to the working appliances. Nowadays most vessels were equipped with cargo-handling gear. That was a necessity for vessels which traded to many of the ports of the world, as often the provision in such places was very primitive. Even at well-equipped ports ships would use their own equipment rather than pay for crane hire. Where the tidal range was great it was difficult to work effectively with the ship's appliances only. The general result was that here with a large tidal range ports were provided with cranes, on the other side of the Atlantic piers without cranes were more common. American piers were, however, provided with cargo hoists, which worked in conjunction with the boom hoists on board the ships, and by means of which the loads were swung further on to the wharf than would be possible by the ship's hoist alone. Most of the older American piers had not been designed to accommodate cranes. They were often merely deck structures supported on piles of considerable length, and lacking in rigidity. The deck was not wide enough to allow of crane tracks being laid. Newer quays were differently built, and it was possible cranes would be adopted before long in New York.

Again, here, most of our railway wagons being open could be loaded direct by crane. In America the box car made that impossible. In many of the modern English ports the standard equipment consisted of 3-ton cranes on the quays. In some cases a large proportion of the cargo was delivered over side to buyers and lighters. This was typical of London and New York; at the latter port also car ferries were a feature. As regards trucking the use of a single unit was characteristic of British ports, with short runs; in America trucks or tractors were used, with trailers. Conveyors were used with excellent effect at Tilbury. So long as the packages were of fairly uniform size they worked admirably. The latter part of the paper was devoted to methods of coal-handling, and the author described a modern American coal shipping pier, and also floating coal elevators, turning subsequently to grain shipment under which heading he referred to the elevator systems of American ports, incidentally speaking of the new machine introduced for emptying box cars of their contents by combined end and sideways tipping.

Visits, &c.

Any account of the Congress would be incomplete without some reference to the number of visits which were paid to numerous works in Sheffield and the neighbourhood at the invitation of the several firms concerned. On the Thursday afternoon visits by parties of members were paid to the River Don Works of Messrs. Vickers, Limited, the East Hecla Works of Messrs. Hadfields, Limited, the works of Messrs. Steel, Peech and Tozer, Limited, and the Parkgate Iron and Steel Company's Works at Rotherham. On Friday the works of Messrs. Cammell Laird and Co., Limited, at Pennistone, were inspected, as well as those of the Stavely Coal and Iron Company, Limited, other parties visiting Messrs. John Brown and Co., Messrs. Thomas Firth and Sons, Limited, and Messrs. Craven's Railway Carriage and Wagon Works.

In addition to these visits members had the privilege of inspecting the Applied Science Department of the Sheffield University. A special train also conveyed a party to Doncaster where the locomotive, carriage and wagon works of the London and North-Eastern Railway were visited. The meeting concluded with whole day visits on Saturday to the docks at Grimsby and Immingham and the Aire and Calder docks at Goole. The selection of visits was thus of a character to embrace all interests in the institution, and greatly enhanced the value of the Congress, while the evenings were spent pleasantly at receptions and conversaziones. On the Wednesday evening, as already mentioned, there was a reception of members by the president, Sir Sam Fay; on Thursday members were entertained at the Town Hall by the Lord Mayor, Alderman W. C. Fenton; and on Friday, at the Cutler's Hall hospitality was extended to the Institute by the Master Cutler, Mr. R. W. Matthews.

INVENTORSHIP.

The Statute of Monopolies which provides that a patent may properly be granted in respect of a new manner of manufacture also states that it shall be granted to the true and first inventor. It does not necessarily mean that only the aforesaid inventor may join in the application for a patent, but his name must be included. Further, according to later statutes and practice it must be included in a particular way differentiating him from the other applicants who are not inventors, and although at first sight this may not appear to be important, legally it has considerable significance. It is of particular moment in those cases where it is ultimately desired to apply for a corresponding patent in the United States of America. If, therefore, two applicants join in an application for a British patent and both claim to be inventors it is necessary that they shall jointly have invented what is claimed. A company of itself cannot be an inventor in the meaning of British law. A company, however, may apply for a patent in conjunction with an inventor, and this is often done, particularly in cases where a company supplies the money for financing the invention.

An inventor includes an importer, and in this way a company may apply for a patent as a communication from abroad. The well-known ½-watt lamp patent is a case of this kind, the patent being applied for by the British Thomson-Houston Company, Limited, as a communication from the General Electric Company of Schenactady in the State of New York, U.S.A. Another instance in which a company of itself can apply for a patent is that wherein the application originated abroad and was filed there in the name of the company, the subsequent application in this country being lodged under the provisions of the International Convention for the protection of industrial property, which enables the priority of the foreign application to be secured for the British patent. Although an applicant may claim to be the true and first inventor of an invention, and so far as he knows may in fact be such an inventor, if it subsequently be found that what he has claimed was published before his application then his patent will be invalid for want of novelty, and in that sense he is not the true and first inventor. This prior publication may be publication by way of document or by way of user. If, however, the application originate abroad, such publication to be effective against the patent must have been made before the date of the foreign patent if the British application is lodged under the provisions of the International Convention. If not, the original applicant is the true and first inventor. An applicant claiming to be the true and first inventor is correct in doing so if, although in fact he may not have been the first to make the invention, whoever made it previously kept it secret. There is a certain amount of doubt as to the effect of secret user based on this prior secret knowledge if that use has been continued up to the date of the patent application referred to, but there is no doubt that if it were not proceeded with until some reasonable period approximating to that date, that the applicant for the patent so far as that prior material is concerned could legally call himself the true and first inventor.

The case of master and servant often rises in connection with patent matters, a person in the employ of another making an invention either in the

course of his ordinary occupation or otherwise. If a patent is applied for, it certainly must be lodged either in the name of the actual inventor himself or in his name jointly with that of his employer, notwithstanding the fact that by reason of the terms of his service or by special agreement the patent when granted and indeed the rights of his invention may belong to the employer as distinct from the inventor. Fiduciary relationship between the parties does not vary the manner of applying for the patent, but only the ownership of it. In the case of inventions communicated from abroad and lodged in the name of a British subject in this country as a communication it must be clearly settled as to who receives the communication, for he alone is the true and first inventor, and a patent would not be valid if it were received by a British subject in this country from abroad, then passed to another and patented in the name of this last person.

There is one other case that gives rise to difficulty on the meaning of who is the true and first inventor, and that is in connection with patents of foreign origin subsequently filed in this country under the provisions of the Peace Treaty, having regard to the fact that British inventors may have filed applications for almost similar inventions in the meantime. This can be dealt with at greater length in a more detailed consideration of the Peace Treaty, but in the meantime reference might well be made to a decided case which bears on the point.

In 1920 a citizen of the United States, by name Armstrong, filed an application in this country claiming priority back to 1913 in view of his United States application. Objection was raised to the grant of this priority by Marconi's Wireless Telegraph Company, on the ground that they had a British patent dated 1918 in respect of similar subject-matter. The difficulty here is to determine which of the parties represents the true and first inventor. This is the first case in which the provisions of the Peace Treaty on this point were publicly decided by the Comptroller-General and according to the report in R.P.C., vol. xxxix, page 146, he decided to grant a patent to the United States' applicant, Armstrong, giving him the priority of 1913, but imposing the condition that the patent granted shall in no way abridge or otherwise affect the right of the Marconi Wireless Telegraph Company or of any other person if *bona fide* in possession of the invention before the date on which Armstrong actually filed his application in this country.

THE CARPET WORKS OF MESSRS. JAMES TEMPLETON AND CO., GLASGOW.

UNTIL within the last 200 years all carpets and rugs were made by the simple process of tying threads of yarn by hand. The ordinary method consisted in the use of two wooden beams, the upper one of which was wound with many threads of yarn which were drawn down and attached to the lower one. These vertical threads formed the warp for the carpet, and tufts of woollen or other yarn were knotted round those threads and a shuttle containing the weft threads was carried across by hand, the interweaving of the warp and weft threads forming the fabric on the surface of which were all the woollen tufts. That process was carried out universally for many centuries in the past and in the East is still the method in use. Unless cheap labour is available economic manufacture is impossible by the hand process, and thus in the Western countries machine manufacture was introduced. To meet the common demands in this country many differing machines were devised and the members of the Institution of Mechanical Engineers will have the opportunity of studying some of them and the various methods of their application at the works of Messrs. James Templeton and Co., at Greenhead, Glasgow, on the occasion of the summer meeting.

The firm of Templeton carry out all the work from the raw materials. The first process is that of spinning, for which the firm have works in both Stirling and Glasgow, and afterwards the yarn is passed on to be dyed and woven into carpets by one or other of the many processes of weaving. The works in Glasgow (see Fig. 1) have a most unusual appearance for a factory, but the proprietors decided that they could not erect an ordinary type of works on a site adjoining a public park. The frontage was actually copied from the ancient palace of the Doges.

The first process in the production of a carpet is design, and is carried out on squared paper, the squares representing the lines of the design both in length and breadth. When the design is completed it is sent to the colouring room, where the worsteds are selected or dyed to suit the requirements. Before the dyeing work is started the yarn is freed from dirt and oil by being passed in hanks through a series of baths of hot water with soap and other cleansing agents, then through clear water and drying rolls. The dye vats usually have capacities of from 130 lb. to 150 lb. but there are some large ones for treating heavier hanks. The yarn is first looped on revolving frames and then sunk into the vat containing cold water and the dyeing material. Steam is applied until the boiling temperature is reached and the operation is continued until the yarn has acquired its desired colour. It is then removed and after drying is wound on bobbins and made ready for use by the weaver.

Of the many processes of carpet making, Messrs. James Templeton and Co., use those for the production of the material known as Chenille Axminster, Imperial or Royal Axminster, Brussels and Wilton.

In the Chenille process, the invention of James Templeton, the founder of the business, there is a double process of weaving. A design is supplied to the weaver and she changes the loom shuttles containing the dyed wool or worsted in conformity with it so that there are many reproductions of each line of the design in the cloth produced. The coloured material forms the weft and is bound into strips by the groups of warp threads (see Fig. 2). When completed the cloth is taken to a machine with a number of circular cutting blades set to strike exactly between the strips and thus cut the cloth into strands. Each strip is composed of a cotton backbone holding the woollen or worsted weft threads which protrude to each side. By pressure the threads are brought together to one side and then the material forms what is known technically as Chenille. After reeling into hanks the long strip is taken to looms (Fig. 3) of width suitable for the intended size of carpet and the Chenille is woven

FIG. 1. THE ALBERT MILLS, GREENHEAD, GLASGOW.

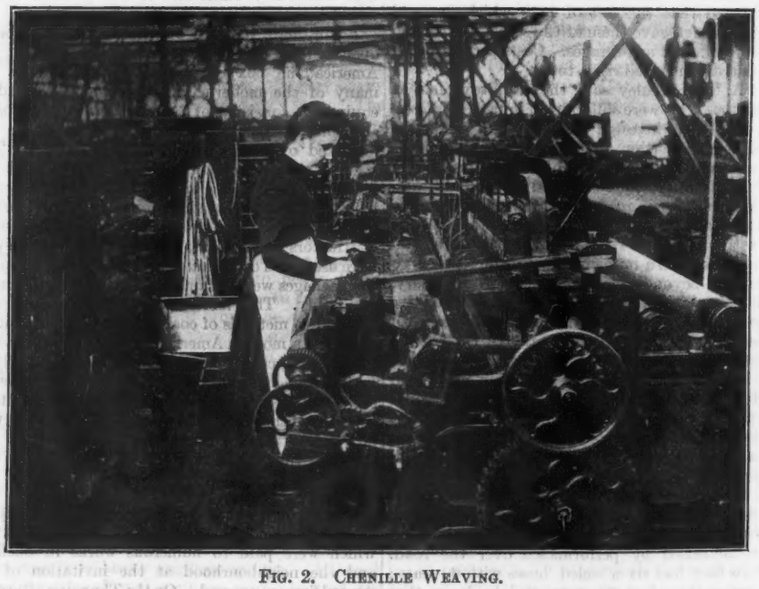


FIG. 2. CHENILLE WEAVING.

into a fabric with a substantial backing. Each one of the strips of Chenille represents a line in the pattern, and they are run in between the binding threads as they are carried quickly across the loom and are then pressed against the others by a heavy lath which is driven forward at the right time. The binding threads lock the strip of Chenille in place against its neighbour and also to the backing. Line on line the carpet is built up until the design is completed, when the weaving process is ended. The carpet is then cropped by passing through between a plain roller and a revolving spiral-bladed cutter (see Fig. 4, on page 776) and after a stiffening process for the backing is completed the carpet is ready for the market.

The process for the production of Royal or Imperial Axminster carpets is quite different. The first page 776). The cards are pierced with holes according to the design of the carpet, and as they are advanced continuously a number of points like heavy knitting needles pass over the surface of the cardboard, and where there is a hole they pass into it. A thread of yarn is attached to the other end of each needle and takes its place in the structure of the carpet. Whether or not the needle passes into any hole in the card settles whether the needle yarn is raised so as to come to the surface of the carpet or remains below, forming part of the backing. There are usually about five sets of warp threads, of different colours and the operation of the jacquard loom fixes which of the five colours will be brought to the surface of the carpet at any point. These Wilton carpets are finished and stiffened in a similar way to those previously described.

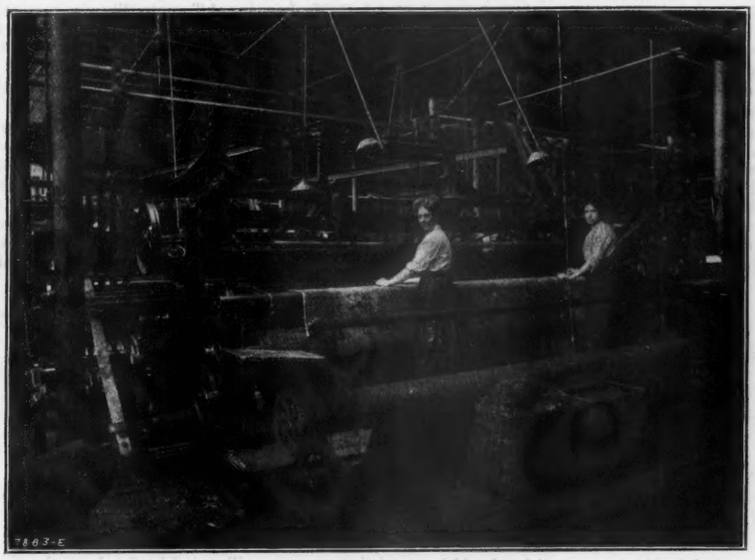


FIG. 3. LARGE CHENILLE LOOM.

operation is that of spooling on a frame such as is illustrated in Fig. 5, page 776. With the design in front of her the girls select the coloured yarn in correct rotation, and a spool is wound with the material for one line of the repeated pattern. The same operation is continued for the next line and so on until spools are available for every line in the design. These spools, 252 of them for an average length of repeat in the design, are then hung in an endless chain above the loom (see Fig. 6, page 776).

As the chain moves on, a series of mechanically-operated nippers is projected forward and these nippers grip each thread. When the threads are drawn out the required extent, a knife cuts them through, and the many small tufts of yarn are then carried by the nippers down to the material and made to form loops on a thread of jute yarn which is firmly woven into the carpet by other warp and weft threads. When the tufts are in place the motion of the nippers continues and they draw yarn from the next spool and so on. The common length between the repeats in the design is one yard, and by the time that amount of carpet is completed the first spool has got round in its travel to position again. The action is quite quick, and in some qualities 30 yards to 40 yards of carpet can be made each day in each loom.

At another of the Templeton works, the Crown-point Factory, Brussels and Wilton carpets are made. In both of these types a looped fabric is produced by the insertion of thin wires right through the width under the surface threads. When the wires are withdrawn a series of loops are left and the carpet with the loops left as they were woven is known as Brussels, while the loops are cut through by a sharp knife edge to form those known as Wilton.

Carpets woven on this system get their designs almost entirely from the warp threads and are manufactured on Jacquard looms (see Fig. 7,

The carpet-making industry is a remarkable one in many ways. Two of its characteristics must appeal to many industrialists. Firstly it enjoys, almost alone, the privilege of being exceptionally busy in these trying times and, secondly, it has had absolute freedom from all industrial troubles such as strikes and lockouts.

THE LIFE HISTORY OF AN ALPHA PARTICLE.

SIR ERNEST RUTHERFORD'S discourse upon "The Life History of an α Particle from Radium," delivered at the Royal Institution last Friday, had originally been planned for March 23. Expressing in his introduction regret for this postponement, which indisposition had necessitated, Sir Ernest remarked that he would have had little heart to discourse on that evening while Sir James Dewar was lying dangerously ill in the same building; the illness terminated fatally within a few days, as our readers are aware.

In the lecture with which we are now dealing, Sir Ernest gave an account of the latest researches in a field that has interested him for more than twenty years. The α particle, he stated, had long been known to be an atom, or more precisely, the nucleus of an atom of helium carrying two positive unit charges, and differing from the atom in the gaseous form inasmuch as it attracted two electrons to itself when coming to rest as a neutral helium atom. The α particle was expelled from a radio-atomic nucleus of that substance, and it was natural active substance as a result of an explosion within the to suppose that the α particle was an entity before this breakdown. It was projected at the high speed of about 20,000 km. per second, and no doubt gained a great deal of its energy in escaping from the strong repulsion by the field of the nucleus in which it had been held; but we knew too little about the nature of the nuclear forces to say whether or not the α particle was relatively at rest in the structure. We did know, however, that the stability of radio-active substances had a wide range; the average life period of radium was 2,200 years, that of uranium 6,000,000,000 years. But the same substance always ejected its particles at the same speed, though different speeds were given for different substances. There was apparently a relation between life period and that speed; substances of long life emitted slow particles, substances of short lives gave fast particles; our knowledge was insufficient, however, to explain the relation.

Connected with this speed was the characteristic property that every particle of a type had a definite range. Measured in air at ordinary pressure and temperature the range was 2·5 cm. for uranium I, 2·9 cm. for U II, 3·8 cm. for radium F, 4·3 cm. for emanation (now called radon), 7 cm. for RaC and 8·6 cm. for thorium C_2. Sir W. H. Bragg had first

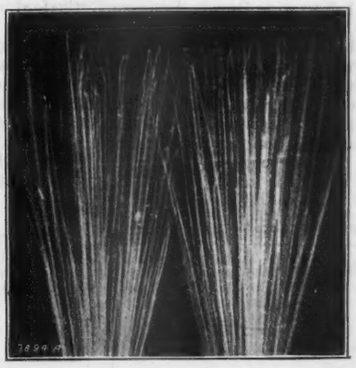
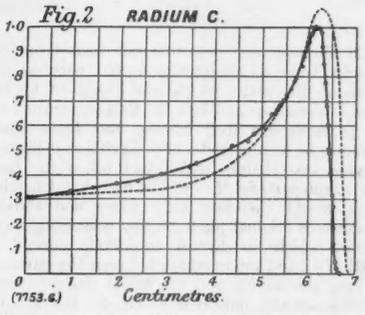


FIG. 1.



drawn attention to the observation that, when the RaC particle had travelled 7 cm. in air all its effects ceased.

Showing some of C. T. R. Wilson's photographs of the ionisation paths of α (and also β) particles passing through moist air, and of P. M. S. Blackett's modification* of the method—in which two photographs are taken at right angles to one another so that perspective effects can be allowed for—Sir Ernest pointed out (Fig. 1) that all the paths were approximately of the same length and ended abruptly. For quantitative research other properties of the α rays, their deflection by electric and magnetic fields, and the momentary light flash which each particle excited when hitting a phosphorescent screen, were more convenient; the flashes could be counted if their number (suitably reduced, if necessary) did not exceed 100 or 150 per minute.

The curves of the range of the α particles from radium C, obtained in this way by Henderson and others, were of the type shown in Fig. 2, in which speed was plotted against range in air. As the particle travelled on, it collided with air molecules, ionised them and lost energy in these encounters; the power of ionisation increased as the speed fell off, but reached its maximum when the range was about 6 cm., then to drop off altogether. In order to

* Compare ENGINEERING, March 16, page 339.

obtain estimates of the velocity and energy losses, screens of very fine gold foil had been used by Sir Ernest and Mr. Marsden (the equivalent stopping power of a material being generally expressed in centimetres of dry air at normal pressure and temperature), and it had been found that the ionising power of the α particle was rapidly lost, when its speed was reduced to 0·4 of its original value, though the speed was then still near 10,000 km. per second.

But some doubt had been left. It was difficult to photograph the effect near the apparent end of the path; comparative experiments in vacuum apparatus were required, and the vacua of those days before the Gaede pump were poor. Resuming these studies lately in the Cavendish Laboratory, with the aid of apparatus similar to that presently to be described, Dr. G. H. Henderson found that the α particles were not all deflected as if they carried the two positive charges ascribed to them; it looked as if some particles had picked up an electron, thereby turning into atoms of single charges. As Dr. Henderson had to go to Canada, Professor Rutherford took this very important research up again.

The apparatus (diagram Fig. 3) consisted of a narrow box, highly exhausted, containing the radio-active source, a vertical slit, 0·3 mm. wide, and a photographic plate. The source S (shown in cross-section) was a platinum wire 0·25 mm. in diameter, coated with RaC and so mounted in a carrier that the particles could only escape in front through a slit, which was mostly covered with a foil of mica. While the magnetic field was not turned on, the particles travelled along the dotted path to the centre of the plate, which was examined by the aid of a microscope. When the field was turned on, the particles described curves, and there could distinctly be seen particles of a maximum deflection carrying two charges which had taken the path He++, and particles He+ of just half that deflection which would therefore only carry one charge. Henderson's original photographs, resembling band spectra, which Sir Ernest exhibited, showed in addition a band intermediate between the particles carrying the double and the single charges (these particles are also indicated in Fig. 3), and a band corresponding to the dotted line of zero deflection of Fig. 3 indicating that electrically neutral particles had struck the centre of the plate; this last He_o band was visible both with the field on and off.

Fig. 3.

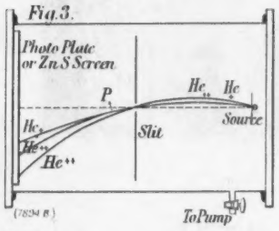


Fig. 4. CAPTURE OF ELECTRONS BY SWIFT α PARTICLES.

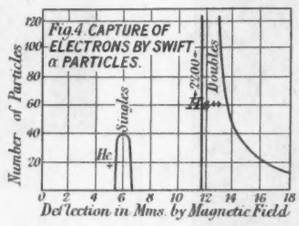


Fig. 5.

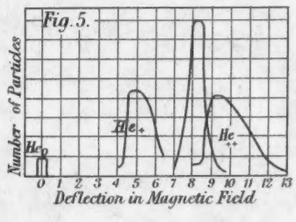
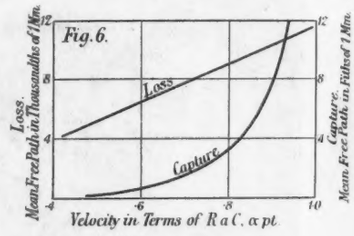


Fig. 6.



Sir Ernest confirmed these observations. By varying the thickness of the mica screen in front of S, which would vary the initial velocity V_0 of the α particles, and other conditions, and later also by admitting gas into the exhausted chamber, he found that the relative number of singly charged particles, first very small, increased as the mica thickness increased, and he obtained distinct curves of neutral, singly-charged and doubly-charged He particles. In Fig. 4 the ordinates of the two curves mark the relative numbers of particles, the abscissæ the deflection of the particles by the magnetic field; there is no neutral particle and the single-charge particles are scarce. As V_0 was diminished, neutral particles made their appearance; but their number always remained small, while the number of single-charge particles increased at the expense of the double-charge particles. Finally the three curves mentioned appeared as in Fig. 5, to which we shall have to revert.

These observations pointed to a capture by the α particles of electrons either from the mica or the gas. Having caught an electron, a particle might move on together with it, but might collide with an atom and with electrons in them, and the caught electron might be knocked off again. The point P in Fig. 3, in which the one curve bifurcates, marked such a collision and loss of an electron. There would thus be both capture and loss of electrons, proceeding until a kind of equilibrium had been set up. Now we might suppose that the α particle would have to travel a certain average distance—which might be called a mean free path—before catching an electron, and another distance before it lost it again. If λ_1 were the mean free path for capture (again in terms of air at normal pressure and temperature) and λ_2 the main free path for loss, N_1 the number of double-charge particles, N_2 the number of single charge particles, then the equilibrium condition would be $N_1/N_2 = \lambda_1/\lambda_2$. The maximum velocity V_0 of α particles from RaC was $1{\cdot}922 \times 10^9$ cm. per second. Reducing in different experiments this velocity to 0·94, 0·76, 0·47 V_0, Sir Ernest found for N_1/N_2 the corresponding values 1/200, 1/67, 1/7·5; from that he deduced a mean free path of 0·011 mm., 0·0078 mm., 0·0050 mm. for loss in air and a mean free path for capture of 2·2 mm., 0·52 mm., 0·037 mm. Thus the mean free path for loss varied as the velocity itself, whilst the mean free path for capture increased enormously with the speed, as the sixth power of V_0, in fact. The diagram, Fig. 6, brings this out strikingly, when we consider that the ordinate scale for loss is in thousandths of a millimetre, whilst the scale is one-fifth millimetre for capture. We recognised also that ionisation diminished when the speed increased.* Calculations showed that the number of single-charge and of double-charge particles should become equal at 0·3 V_0; the observations gave 0·29 V_0. Similar considerations applied to the neutral particles.

Sir Ernest further investigated whether the single charges were necessarily connected with the mica, removing for this purpose the mica screen, through which the particles had so far passed. To his surprise he found that the single charges still appeared conforming to the equilibrium condition. Measurements were difficult; but it seemed clear that there was an equilibrium distribution already in the particles as they left the source. The α particle would come from the nucleus of the RaC; in escaping it would have to pass through a dense distribution of electrons in orbital movement, and when it came to the slower electrons of the outer orbits, it might catch up an electron and lose it again, while still within the same atom. It was interesting in this connection that other observations proved collisions from inside to be more effective than collisions from outside. When gas was admitted into the chamber the curves of Fig. 5 finally changed; the three distinct curves so far spoken of vanished and were replaced by the fourth compressed high-peaked curve [not otherwise marked] at abscissa 8. That observation again verified the probability of captures; by admitting hydrogen gas (instead of air) into the chamber it was further proved that capture was possible even in the lightest and most simple gas.

How were the phenomena to be interpreted? The rapidity of the captures was great. There were a thousand per minute down to $V_0 = 0{\cdot}3$, and as many more probably along the whole path of the particle, and one might well ask why a swift α particle should capture an electron at all? The chances appeared infinitely remote also from the energy point of view. The velocity V_0 corresponded to a potential difference of about 1,000 volts, and when the α particle swept past an electron and caught it, that whole energy had to be dissipated. The capture might occur close to a nucleus; but after all it had been proved that capture was possible in the simple hydrogen atom which 20 volts would knock to pieces, as well as in the heavier complex oxygen atom (of air). We were driven to the assumption, Sir Ernest continued, that the energy was lost in radiation, by a kind of inverse photo-electric phenomenon. In this latter phenomenon, radiation was captured and an electron was ejected; here an electron was captured and radiation was emitted. If that were so, some 3 per cent. of the energy of the α particle should go out in soft radiation and invisible light. We did not know that yet. Sir Ernest made an indirect appeal to Professor Niels Bohr, of Copenhagen (who was present), to take that problem up, congratulating also Professor J. C. MacLennan, of Toronto (likewise present), for his manufacture of helium and his work in these fields.

Coming to his conclusion Sir Ernest said that a free α particle might then capture and lose an electron and become neutral. But suppose it were imprisoned in rock, *e.g.*, in the lump of samarskite lying on the lecture table, which probably contained 20 litres of helium. That helium had been bound for many millions of years, and yet might be released by grinding the mineral up and heating it in a quartz tube. This was done by Sir Ernest's assistant, Mr. Crow. Within a minute or two the helium made its appearance in an electric discharge tube, the other gases liberated having been absorbed by charcoal. The life history of an α particle, Professor Rutherford concluded, was strange. For millions of years it was at rest within some radioactive material. A catastrophe within the atom released it, and for a thousand-millionth of a second it became the most powerful projectile known, to turn into an inert gas, which again might be imprisoned in minerals for millions of years. All the helium, now isolated in quantities to fill large balloons, had passed through this life.

* Professor Rutherford had explained this peculiarity in his fourth lecture on "Atomic Projectiles"; see ENGINEERING, March 16 last, page 338.

TRADE WITH SWITZERLAND.—Mr. E. C. D. Rawlins, who has been commercial secretary at Berne, will be in attendance at the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, from June 25 until June 29, and will be prepared, during that period, to interview United Kingdom firms interested in trade with Switzerland. Applications for interviews, which must be by appointment, should be addressed to the department and the reference 4,780/T.G. quoted.

THE BRITISH CAST-IRON RESEARCH ASSOCIATION.—The secretary of this association reports that possibly no industry more than the ironfounding industry requires assistance such as can only be given by research. In the cast-iron field metallography has not been made use of to the extent that it has in the steel industry. A few metallurgists have developed the microscopic study of malleable iron until the annealing operation is becoming better understood, but little of practical value for the grey-iron foundryman has been obtained through microscopic investigation. For example, the microscopic investigation of carbon in grey iron has been confined largely to examining the shape and size of the graphite particles. Investigations by the association point to the complexity of the graphite grain of which graphite is only a part. Possibly when the nature of the graphite particle is understood, a method of controlling it to give higher physical properties to the grey-iron may be evolved. Once these problems are solved the results will be turned over for practical application. The beneficial results arising from work of this character can only be measured as the various problems awaiting solution are dealt with by the association. The problems now being investigated include pin holes in cast-iron rolls, mixture for special cast-iron retorts, Diesel engine cylinder heads, &c., researches in connection with the malleable iron industry and foundry sands.

INDUSTRIAL NOTES.

THE monthly review issued by the Ministry of Labour states that there was little change, on the whole, in the state of employment during May. In the coal-mining industry, in tin-plate and steel sheet manufacture, and in the carpet trade it continued good; and in the iron and steel, paper, printing, and brick trades it was fair. In most of the other large industries it was still slack, but a further slight improvement was reported at iron mines, in pig-iron manufacture, in certain other sections of the metal trades, and in the building trades. There was a decline, however, in the wool textile industry, and the shipbuilding industry was affected by the lock-out of platers, riveters, &c. The percentage unemployed among members of trade unions from which returns are received was 11·3 at the end of May, as compared with 11·3 at the end of April, and with 16·4 at the end of May, 1922. The percentage unemployed among workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland was 10·7 on May 21, as compared with 10·9 on April 23, and 13·5 at the end of May, 1922. The total number of workpeople registered at the Employment Exchanges as unemployed on May 28 in Great Britain and Northern Ireland was approximately 1,261,000, of whom 959,000 were men and 229,000 were women, the remainder being boys and girls. On April 30 the total was also 1,261,000, of whom 963,000 were men and 218,000 were women.

In the industries for which statistics are collected by the Labour Department the changes in rates of wages reported as having taken effect in May resulted in an aggregate reduction of nearly 100,000*l.*, in the weekly full-time wages of nearly 900,000 workpeople, and in an increase of over 90,000*l.* in the wages of 700,000 workpeople. The number of workpeople affected by increases in wages and the total amount of increase are the largest recorded in any month since January, 1921. The largest group of workpeople whose rates of wages were reduced were building trade operatives, who sustained reductions, in the majority of districts, of ½*d.* or 1*d.* per hour in the case of craftsmen (with an additional reduction ranging from ½*d.* to 1½*d.* per hour in the case of plumbers in London and certain other localities), and of ½*d.* to ¾*d.* per hour in the case of labourers. Other classes of workers whose wage rates were reduced included electric cable makers, heating and domestic engineers, cement workers, compositors in provincial towns, and tramway workers. Under the Trade Boards Acts there were reductions in the minimum rates fixed for workpeople in a number of trades. The principal groups of workpeople who obtained increases in wages were coal miners in Northumberland, Durham, Yorkshire, the East Midlands, Scotland, and the Radstock district; the amounts of increase varied, in different districts, from 2½ per cent. to 7 per cent. on current rates. There were also increases in the wages of iron miners in Cumberland, Furness and Lincolnshire, blast-furnace workers in Cumberland and Lincolnshire, iron puddlers and millmen in the North of England and the West of Scotland, and Siemens steel workers in South and West Wales. During the first five months of 1923 the changes in rates of wages reported to the Department have resulted in a net reduction of 340,000*l.* in the weekly full-time wages of 2,350,000 workpeople, and in a net increase of over 100,000*l.* in the weekly wages of 760,000 workpeople. In the corresponding five months of 1922 there was a net reduction of nearly 2,320,000*l.* in the weekly wages of 7,000,000 workpeople, and a net increase of 3,000*l.* in the wages of 17,000 workpeople.

On June 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour was approximately 69 per cent. above that of July, 1914, as compared with 70 per cent. on May 1. For food alone the corresponding percentages were 60 and 62 respectively.

The number of trade disputes, involving stoppages of work, reported to the Department as beginning in May was 49. In addition, 41 disputes which began before May were in progress at the beginning of the month. The total number of workpeople involved in all disputes in May was about 48,000, compared with 110,000 in the previous month and 382,000 in May, 1922 (when disputes were in progress in the engineering and shipbuilding industries, involving about 350,000 workpeople). The estimated aggregate duration of all disputes during May was 807,000 working days, as compared with 1,077,000 days in April, 1923, and 7,879,000 days in May, 1922.

At the National Conference between the Executives of the National Federated Electrical Association and Electrical Trades Union, held at Leicester on May 29, the following resolution was passed in connection with the National Standardised Wages Agreement: "That there be no alteration pending a review of the whole situation in January, 1924. In the meantime, wages be stabilised on the current rates of all grades, until February 1, 1924."

In the summary, No. 29, on the coal industry recently issued by Mr. Philip Gee, 40, King-street, Covent Garden, W.C. 2, reference is made to the wages agreement; this, it is said, is a profit-sharing agreement, under which the men received 18*s.* 7*d.* out of every pound that the coal-mining industry made in 1922, after paying costs other than wages. The agreement provides a minimum wage equivalent to 20 per cent. above the standard wage; at present the minimum wage varies from 7*s.* 9*d.* to 9*s.* 8*d.* per shift, according to the district. There are only three alternatives to an increased wage derived from increased profits under the agreement: (*a*) A Government subsidy (throwing cost upon the taxpayer); (*b*) an increase in number of hours worked below ground; (*c*) an artificial increase in the price of coal to the consumer. The alternatives under (*a*) and (*b*) have been refused; (*c*) would entail an average increase in the price of coal of 3*s.* 4*d.* per ton. The actual increase in the cost of living to the miners has never been satisfactorily established, as the Board of Trade figure of 70 per cent. does not make any allowance for the cheap coal and housing accommodation which are special privileges of the miners, and the Board of Trade figure of increase for food alone is 62 per cent. According to the Secretary for Mines, the miners' average wage for Great Britain was 6*s.* 5½*d.* in June, 1914; in May and June this year it is 9*s.* 11*d.* A wage 70 per cent. above June, 1914, would come out at 11*s.* 0½*d.* Against the claim that the 1914 wage was a bare subsistence wage may be put the statement by Mr. Vernon Hartshorn, before Lord Buxton, the independent chairman for South Wales, to the effect that the miners' wage in 1914 was about 20 per cent. above the subsistence level. (It will have been noticed from one of the preceding notes that the retail prices are now 69 per cent., and for food alone 60 per cent.)

A trade union case was heard last Tuesday by Mr. Justice Horridge and a jury at the Monmouthshire Assizes. A number of miners, members of the Miners' Federation, had attacked members of the Mechanical and Surface Workers' Union. They were charged with riotous assembly and with damaging the house of an official of the latter union. In addressing the jury, Mr. Justice Horridge said that if they accepted the evidence of the police, they were bound to say that the case against all the accused had been proved up to the hilt. The law, he added, had been extended to trade unions and these had all legitimate right; they had the right of peaceful persuasion and the right to picket, but not the right to terrorise the inhabitants of a place in order to enforce their mandates upon a man who was doing something which he thought was perfectly right. All the accused were found guilty. Six were sentenced to four months hard labour; a seventh who had taken part in a riot on a previous occasion was sentenced to six months hard labour. Mr. Justice Horridge further stated that all the witnesses for the defence had come to the court with the intention of telling lies, and he would therefore disallow their expenses.

"THE ORIGINAL UNIFLOW STEAM ENGINES."

TO THE EDITOR OF ENGINEERING.

SIR,—"The uniflow principle invented by J. L. Todd in 1885" is the opening sentence in an article on page 742, ENGINEERING, June 15, 1923. It may be news to some of your readers to learn that the uniflow engine, simple and compound, was invented and made by Jacob Perkins in 1827, and appears, from contemporary literature, to have created more interest on the Continent than in England. The Perkins engine was of the boat-type with short vertical cylinders, its distinguishing feature being ordinary-length vertical cylinders with single ordinary single-head pistons (as in all single-acting cylinders); the compound type had two cylinders, side by side, each piston acting on a separate crank. The compound, and also the simple engine, had only one admission valve and no exhaust valve; in the compound engine the high-pressure piston acted as the admission valve for the low-pressure cylinder. A replica of the two-cylinder type, but non-compound, for the present, at least, is made in very small sizes by the Jackson-Rigby Engineering Company, Limited, Shalford, Surrey. Perkins provided all safeguards against high compressions when working non-condensing, hence his name: "safety-engines."

Some sixty years after Perkins, Todd arranged in tandem two "Perkins" cylinders, placing the two exhausts together, so forming two cylinders in one, with either two separate pistons, or one "clubbed" double piston, the result being a tandem single-acting engine; and Stumpf, still later, re-introduced, at first, the latter "double" form, but, later on, the original Perkins "single" type, substantially as constructed by Perkins; and, in his well-known book, declared it to be the most economical of all uniflow types working single-expansion. Having only a single-length cylinder with ordinary single pistons, the Perkins engine was lighter and simpler than any other uniflow engine commonly made until Stumpf reintroduced it in boat engines with multiple cylinders and balanced crank efforts. While the notion is largely prevalent that the Perkins single-expansion single-acting engine is most economical of all when it is worked at very short cut-offs and with the lowest M.E.Ps. obtainable, practice has shown this to be a mistake; and a transatlantic contemporary recently reproduced the curve of steam consumptions for various rates of cut-offs and M.E.Ps., the highest (initial) part of the curve of steam consumption commencing with low M.E.P.s and ending with the highest M.E.Ps. (= long cut-offs), the lowest bend of the curve being reached with the medium M.E Ps. and rising once again slowly as the M.E.Ps. increase, but still not reaching again the same high rate of superheated steam consumption as with the lowest M.E.Ps. and cut-offs. It is very interesting to observe that precisely the same order of consumption curve is invariably found in steam locomotive operation, the lowest superheated steam rate per indicated horse-power hour, and the lowest fuel consumption per million ton-miles, being obtained with medium cut-offs of 31 per cent. to 32 per cent.—the steam and coal consumptions increasing when the cut-off is either progressively decreased or increased. In commercial operations on the railways, as also in locomotive laboratories, the results uniformly prove the rule, with all classes of locomotive, simple and compound; and stationary engines—uniflow—appear to be subject to these same conditions affecting their steam economy per horse-power-hour.

Yours faithfully,

CHARLES R. KING, M.I.C.E.(Fr.)

"Elmcroft," East Finchley, N. 2, June 19, 1923.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society, held on Thursday, June 14, 1923, Mr. T. Smith, M.A., F.Inst.P., vice-president, in the chair, the following papers were read and discussed:—

"*Levels and Level Bubbles*," by Mr. S. G. Starling, A.R.C.Sc., B.Sc., F.Inst.P. The paper deals with the factors affecting the efficiency of levels of the bubble form. The results are given of measurements of the density, surface tension, and viscosity of several liquids, *e.g.*, benzol, xylol, chloroform, alcohol and ether, which are used in levels and the corresponding measurements on petroleum others distilled at various ranges of temperature, the ether distilled at 40 deg. to 50 deg. C. being largely used for levels. Measurements are also given connecting temperature and length of bubble with tubes of the ordinary cylindrical type, together with the relation between the damping of the movement of the bubble and its length, and the relation between damping and diameter of tube. The calibration of levels is discussed with particular relation to the presence of faults in the tube. The determination of the longitudinal radius of curvature of the tube is made, as well as the effect of departures from the circular form upon the calibration curve of the level. A new method is described of obtaining calibration curves, by photographing the image of the bubble in a plane mirror, so that the position of the bubble upon the scale is obtained for successive tilts given to the tube. The relations between temperature and width and depth of bubble are obtained, and the results applied to an explanation of the "constant" bubble of Messrs. E. R. Watts and Son, Limited, which has the same length at all temperatures.

"*The Primary and Secondary Image Curves formed by a Thin Achromatic Object Glass with the Object Plane at Infinity*," by Mr. E. Wilfred Taylor. The shapes of the primary and secondary image curves formed by a thin simple lens of an object plane at infinity are well known, and can be readily determined. The object of the paper is to show that the image curves in the case of a double object glass of ordinary thickness, and with the inner curves approximately in contact, correspond very closely to those of a simple lens of the same power, and are only very slightly affected by the use of different glasses.

"*A New Form of Balloon Theodolite*," by Mr. T. F. Connolly, M.Sc. The paper describes a new type of theodolite designed primarily for the observation of dritting balloons where it is desired to follow as closely and consecutively as possible the movements of the balloon, and to note periodically the time and the simultaneous altitude and azimuth observed. The horizontal and vertical circles are brought together in such a way that a single index serves for reading both. A large field achromatic magnifier is so arranged that a "stand-off" view is secured. The magnification is such that the necessary readings and estimations are easily made. The usual vernier has been abolished and replaced by a single index. Estimations of the degree intervals are made on each circle to one-tenth of a degree.

A new "dead-beat" compass was exhibited by Messrs. Henry Hughes and Son, Limited. This compass is of the liquid type, but is modified so as to obviate the disadvantages of the ordinary liquid compass. By the use of two very powerful short magnetic needles the tendency to sluggishness is overcome. Fine radial filaments attached to the card damp out oscillations by virtue of the high eddy resistance they produce and the small increase of inertia that they involve.

PERSONAL.—Mr. E. W. PETTER has been elected president of the British Engineers' Association. Mr. Petter is well known in the engineering world; he is chairman of Petter's Limited, Yeovil, and managing director of Vickers-Petters, Ipswich.

AIR COMPRESSOR AND CARGO OIL PUMP.

CONSTRUCTED BY MESSRS. G. AND J. WEIR, LIMITED, ENGINEERS, CATHCART, GLASGOW.

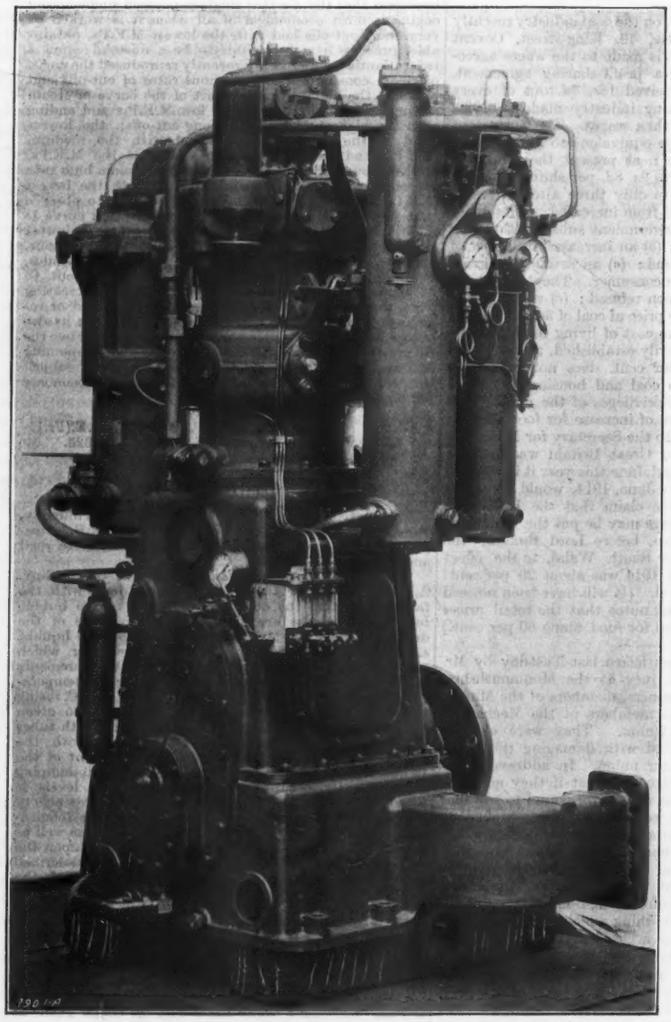


FIG. 1.

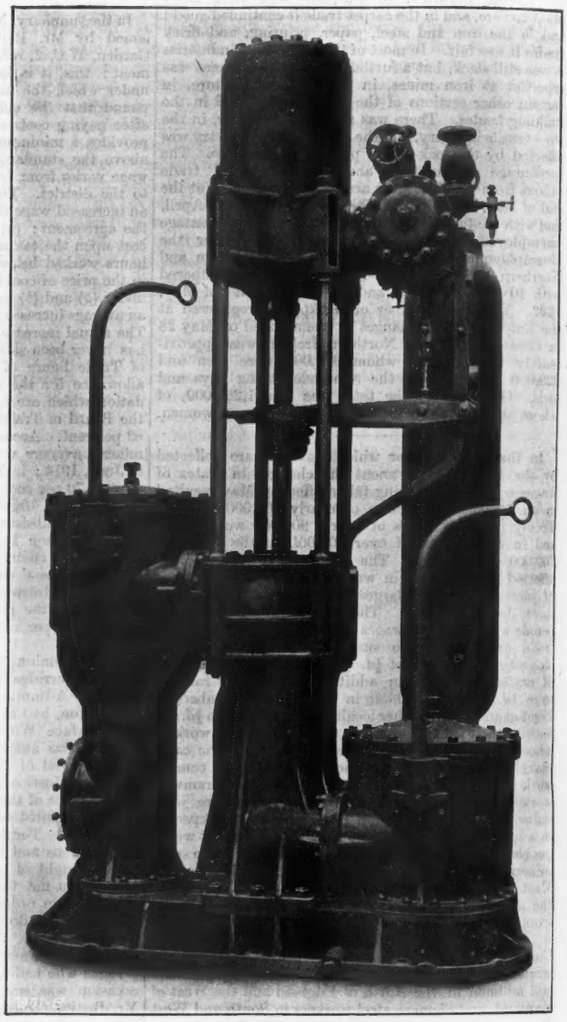


FIG. 2.

AT the works of Messrs. G. and J. Weir, Limited, at Cathcart the members of the Institution of Mechanical Engineers will have the opportunity, on the occasion of a visit during the summer meeting at Glasgow, of studying the standardised production methods adapted in the repetitive manufacture of feed pumps and the other auxiliaries in which the firm specialises. Much of interest to the works designer arrests attention in the various shops, which show in their lay-out and equipment a commendable endeavour to facilitate maximum production. Of greater interest than the actual works, however, are the plants under construction. The feed pumps which are known for their sound design and construction and reliable working throughout the entire engineering world need no comment, but there are some products of the firm which are perhaps not so well known, but which may be seen at present in the process of construction, and in operation in the test house. Examples of these are illustrated on the present and opposite pages. The examples chosen are representative products of the firm and comprise an air compressor, a cargo oil pump, and a turbine-driven circulating pump.

One of the two Weir-Murray-Workman auxiliary air compressors for a motor vessel which is being engined by Messrs. W. Rowan and Co., Limited, of Glasgow, is shown in Fig. 1. The plant is capable of dealing with 175 cub. ft. of free air per minute and compressing it and delivering it at 1,000 lb. per square inch. A crude oil engine of the "Plenty" type will drive the compressor at 340 r.p.m.

The compression is carried out in three stages and between them the air is passed through straight tube coolers to reduce the temperature before further compression. There is a valveless oil pump on the crankshaft end which supplies the oil for the forced lubrication system, and pipes or ducts convey the oil to all bearing surfaces. The piston lubrication is effected through sight feed lubricators, delivering oil to each of the three stages. The high pressure piston is situated above the low pressure one and the annular space between the high pressure piston and the top of the low pressure cylinder is used for the intermediate compression. The crosshead is fitted with adjustable slippers which work in bored cast iron guides. Protection of the cylinder walls from oil splash is afforded by a plate on top of the crosshead.

The coolers have safety blow-out discs fitted to them for protection in case any of the tubes should burst. For repairs or for cleaning, the tubes and the tube plates can be easily and quickly withdrawn from the body of the cooler and spare units may be kept to reduce the time out of action. At each of the three stages in the compression a large relief valve is fitted. The air valves are all of the same design, whether for suction or delivery, and are completely interchangeable. They are automatic, very light and have a small lift while they can be taken out by the simple process of removing the valve chest covers. The cylinders have renewable liners made from a special grade of cast iron. For marine purposes it is even more essential than in land practice to have air compressors which work reliably and silently for long periods with the minimum of attention, and this was particularly borne in mind in designing the details of the construction of these plants.

The adoption of oil fuel for steam raising on board ship necessitates the introduction of three types of pumps—pressure pumps to force the fuel through the burner nozzles, transfer pumps to lift the oil from the bunkers to the settling tanks, and cargo pumps to deliver oil between the ship and the shore. All three have distinctly differing duties and must be specially designed for their specific purposes.

The illustration in Fig. 2, above, shows a Weir cargo oil pump with steam cylinder diameter 18 in., oil pump cylinder 16 in., and having a stroke of 30 in. It is of the Weir simplex direct-acting type and suitable for the delivery of 300 tons of oil fuel per hour when running at 30 double strokes per minute. The ports and passages are of large dimensions and arranged to give a free and uninterrupted course, while the parts are easily accessible for examination or overhaul. The steam valve gear is of the well known Weir type. The pump ends are fitted with large air vessels and relief valves providing a return to the suction side of the system. The ring type of valve which is used gives large area of flow while taking up very little space. If designed for the use of oil only, the pump ends and the buckets are made of cast iron and the valves are of steel and work on cast iron seats. Should it be required that the pump may also be used as a ballast pump, brass linings are provided

TURBINE-DRIVEN CENTRIFUGAL PUMP.

CONSTRUCTED BY MESSRS. G. AND J. WEIR, LIMITED, ENGINEERS, CATHCART, GLASGOW.

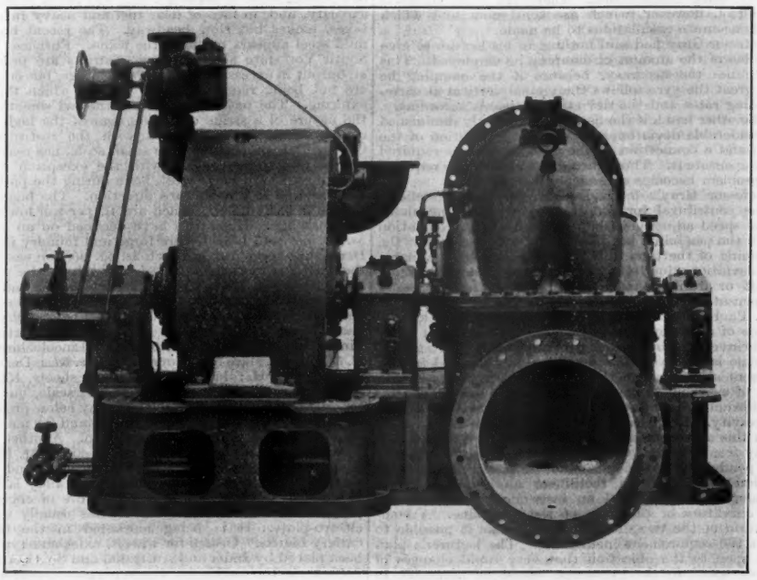


FIG. 3.

for the pump ends and the valves and seats are made of gunmetal.

Fig. 3, above, illustrates a turbine-driven centrifugal pump which was recently supplied to the Birmingham Electricity Department. Each condenser in the installation for which the pump was designed is arranged with two circulating water-pump units, the one electric and the other steam turbine driven.

The set illustrated delivers 9,700 gallons of water per minute against a total head of 51 ft. when running at 1,370 r.p.m. Actually this corresponds to meeting 60 per cent. of the total full load demand. The steam used in the turbine enters at a pressure of 300 lb. per square inch and superheated to a temperature of 750 deg. Fahr., and the exhaust is taken away to a feed heater at a pressure of about 5 lb. per square inch gauge. The steam turbine is of the pressure compounded type with three stages. To withstand the high pressure and temperature, the turbine casing is made of cast steel, and the first stage nozzle and blading are made of monel metal. The pump has been made of special design to deal with the large quantity of water at high speed. There are two impellers fitted and they run in parallel, each having a double inlet. By adopting this construction the outside diameter of the impellers has been kept down to 13 in. Both steam and water rotors are mounted on the one shaft which is supported on three bearings, fitted with double ring lubrication, and the oil in the turbine bearings is water cooled. Governing is effected by the throttling of the steam supply. The governor is mounted directly on the end of the shaft. In the event of the pump losing water, there is an emergency governor which operates a trip gear and so closes the main stop valve.

NOTES ON NEW BOOKS.

The inquiry into the effects of war upon social and commercial life, conducted under the auspices of the Carnegie Endowment for International Peace, has been mentioned in these columns on more than one occasion, for the scheme embraces a large horizon and touches many interests. The latest volume to be published is devoted to "*Trade Unionism and Munitions*" (The Clarendon Press, Oxford, Price 7*s.* 6*d.* net.), by Mr. G. D. H. Cole, an authority who is entitled to speak, for he acted as adviser to the Amalgamated Society of Engineers throughout the period of the war. He had therefore opportunities for acquiring information from the trade union side. We are reminded by the author that we are still living in the war period under the influence of the acts to which it gave birth. Looked at from this limited point of view, several questions are raised which can be studied with good effect. Prominent among these is the gradual obliteration of distinction, based on the difference of grade and skill, leading to the production of a more homogeneous proletarian order. The introduction of machinery was the great factor in destroying the pre-eminent position enjoyed by the highly-skilled craftsman, but the process of "dilution," understanding the word in its widest sense, rendered necessary by the urgency of war, undermined the position even more decidedly. The decay of the system of apprenticeship was not without its influence. The less skilled and less trained machine minders were necessarily advanced, while in their turn, the place of these less competent operatives was invaded from a lower stratum, and the lines of demarcation became less recognisable. The effect of this work of amalgamation and its effect on trades union organisation is one of the subjects that has been critically studied, and the production of the original documents is a valuable contribution to the literature of a subject where verbal construction will be much disputed. Another material point is the consequence of the substitution of the labour of women for that of men. This step was imperative owing to the stern refusal of trades unionism to admit coloured labour. The entrance of large numbers of women, particularly in the metal trades, to compete with the occupants of the lowest class had still further the effect of pushing the male worker towards the highest class of job he was capable of performing. The author claims that the endeavour to derive the fullest and most valuable service from the workers was neither effectively nor tactfully done.

Twenty years ago Professor Ferdinand Wittenbauer, of the Technical High School, Graz, Austria, set himself the problem, given the forces, resistances and mass distribution of a mechanical gear, to find the velocities and accelerations of the parts determining its working. Solutions of complex dynamic problems of this kind by calculation look almost hopeless. Wittenbauer found a general solution by graphic methods; but it took him twenty years to work it out, and he died while revising the proof sheets of the "*Graphische Dynamik*" [Berlin: Julius Springer; price 16*s.* 8*d.*]. As a general text book for students and engineers the volume is probably unique. Whether many engineers will find the time to study the 797 pages with 745 text figures in order to make themselves sufficiently acquainted with the graphic methods to apply them in their profession, appears rather doubtful, in spite of the examples given, particularly in view of the fact that frictional resistance is disregarded. Wittenbauer first outlined his graphic dynamics in the *Zeitschrift für Mathematik und Physik*. We are afraid that his life work will be considered more suitable for the columns of a mathematical periodical than for an engineer's hand book, as long, at any rate, as graphic dynamics are not one of the subjects of the engineer's college training. We should mention, however, that Wittenbauer does not presume more than average mathematical knowledge in expounding his method.

Increased attention has been directed to the achievements and possibilities of wireless telephony by the facilities offered for transmitting intelligence and providing recreation by "broadcasting," and many attempts will no doubt be made to satisfy the curiosity of those who are intelligently interested in the principles and mechanism by which the results are accomplished. Dr. Erskine-Murray has written much on the subject of telephonic transmission, and his book on "*Wireless Telephones*" (London: Crosby, Lockwood and Son. Price 4*s.* 6*d.* net) has been so well received that it has now reached its third edition. It provides a short readable account of the underlying principles which permit sound waves, by changing the strength of an electric current at the transmitting end, to be heard in a distant receiver, but gives very few details of the necessary mechanism. It is impossible to say how far such an account as that given will enable those, who approach the subject without any previous knowledge, to comprehend the process, but one feature will hardly prove of any assistance. Certain technical terms are introduced without any, or with insufficient, explanation, and to meet the defect, a glossary of technical terms is given at the end. Even if this glossary is used, the information supplied is not very full or satisfactory, and in any case the reference to it must interrupt the reading and prove a source of vexation. There is a chapter on the history of the development of the process, in which it is noticeable that the discovery of the three-electrode thermionic valve, "the parent of those now used almost universally in radio-telephony both for transmission and reception" is credited to Dr. De Forest. The omission of all reference to Professor Fleming's share in this epoch-making device is to say the least, remarkable. In a final chapter the author urges the extension of wireless telephony throughout the Empire, scattered so widely over the Globe, as a means for averting the evil consequences of isolation, which threaten the more remote portions. We would cordially support the realisation of any such scheme, believing that the establishment of a series of links through the whole range of Empire would tend to promote the interests of all, and bind the whole together in mutual support and common purpose.

We are familiar with certain dramas, which, being written to be acted, gain immensely by connection with the mechanism of the stage, the artistry of the actors, and the subtleties of technique. These plays when read apart from the blandishments of histrionic representation often fail of their due effect and impressiveness. Similarly it might be urged that there are stories in science of entrancing interest, "fairy tales in science," Professor Fleming calls them in his work on "*Electrons, Electric Waves and Wireless Telephony*" (London: The Wireless Press, Limited; price 7*s.* 6*d.* net) which, when presented before an audience with all the art of the accomplished lecturer, aided by carefully constructed diagrams, and illustrated by the oft-practised experiment that appeals so powerfully to the eye, exercise a wonderful charm, and persuade those who listen that they have mastered the intricacies of some complex subject and solved all the difficulties that stood in the way of distinct comprehension. In a word, the lectures are eminently successful. But when those lectures are prepared for close study and private reading the sparkle, due presumably to the personality of the lecturer, seems to have disappeared and we are left with a tame and flat reminder of past success. This is the kind of feeling we have in reading the reproduction of Professor Fleming's lectures at the Royal Institution in the winter of 1921–22. Of course, the matter is correct and not unskilfully presented, and many may prefer to sip slowly and thoughtfully the information, so bountifully provided in the short limits of a lecture. It is only by comparison with the effectiveness of a lecture that any sense of disappointment can arise, a disappointment due apparently to the effort to cover too much ground. The first lecture is devoted entirely to the formation and behaviour of surface waves, the second mainly to sound waves in air, a rather lavish expenditure of a strictly limited amount of space. In the third lecture, the architecture of atoms, we get nearer to one of the subjects mentioned in the title, but in the next, we wander rather aimlessly among such subjects as Mendelieff's periodic table of the Elements, Planck's Quantum Theory, and the theory of relativity and least action, inspiring subjects for contemplation, but requiring more space for development than is possible here. In the fifth chapter more practical matters are introduced, and the author is happy in his historic retrospect which leads naturally to the discovery and use of the thermionic valve. In the final chapters on speech transmission and the

principles of wireless telephony, Professor Fleming's familiarity with all modern apparatus gives him an immense advantage, and the hand of the master conjuror is seen at its best in describing forces and methods that yield excellent results now, and point to still more interesting results in the near future.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on the 8th inst., at the Imperial College of Science, Dr. Alexander Russell, M.A., D.Sc., in the chair, Professor James G. Gray, D.Sc., F.R.S.E., Cargill Professor of Applied Physics in the University of Glasgow, delivered a lecture entitled "*A General Solution of the Problem of Finding the True Vertical for all Types of Marine and Aerial Craft.*" The lecture was accompanied by demonstrations with gyroscopes. In the first part of the lecture it was shown that the difficulties presented by this problem arise from the horizontal accelerations which result from the turning of vehicles. A gyroscopic pendulum to succeed must possess a real precessional period, or a virtual precessional period during turning motion of the vehicle on which it is mounted, which is measured in hours.

Pioneer forms of Gray stabiliser were described. These were devised by the author and his brother for use in the Royal Naval Air Service. A system composed of a single gyroscope (mounted with its axis normally vertical) and an erector connected rigidly to one another, is pivoted to a gimbal frame by means of two cross pivots; and this frame is in turn attached by means of fore and aft pivots to uprights, or the equivalent, carried by the aeroplane. The system composed of the gyroscope and erector is mounted and balanced up so that the centre of gravity of the entire system coincides with the intersection of the pivot axes.

Various forms of erector made use of with these pioneer instruments were described, and their dynamical action discussed. One form consists of a circular track carried by the pivoted system, and so arranged that when the pivoted system is upright the track is horizontal. One, two, or more balls rotate on the track, each controlled by a pusher and a check carried by a member which rotates slowly (about 12 r.p.m.) in the direction of spin of the gyroscope. When the system is upright the balls move round the track in contact with their pushers, and form a balanced system. When the system is inclined to the vertical the track is inclined to the horizontal, and each ball when ascending the slope of the track rests against its pusher, but after crossing the crest of the slope it is accelerated down the track and rests against its check. The motion of the balls relative to the pushers and checks results in the application to the pivoted system of an integral erecting couple. It was shown how the contrivance could be arranged so that the stabilisers possessed the property that it was blind to the apparent vertical during turning motion of an aeroplane on which it was mounted, but conscious (so to speak) of the true vertical during the ordinary flight of the aeroplane.

These pioneer forms of the instrument were found to possess an accuracy, for bombing purposes, amounting to one-eighth or one-tenth of a degree, or about 20 ft. on the ground from a height of 12,000 ft. Previous work on the problem failed because the devices produced possessed the property that they left the true vertical quickly in the presence of the accelerations which accompany turning motions of the aeroplane, and returned to the true vertical only very slowly after the resumption of ordinary flight. The pioneer forms of Gray stabiliser (when properly used) moved only very slowly, if at all, towards the apparent vertical when the aeroplane was turning, and after the resumption of ordinary flight moved towards the true vertical (supposing an error to exist) relatively quickly.

Finally the latest forms of Gray stabiliser were described. These set themselves into the true vertical even when the vehicles on which they are mounted are turning, and this holds for all speeds of turning. Control is never lost. This result is obtained by constructing the apparatus so that a horizontal component of spin lies across the pivoted system, that is, parallel to the cross pivots. The pivoted system is mounted so as to be pendulus with respect to the pivots, and the direction of the horizontal spin, and its amount, is arranged so that when the vehicle turns there comes into existence a gyroscopic couple, applied about the fore and aft pivots, which is exactly equal and opposite to the so-called centrifugal couple applied to the pivoted system. Both couples are proportional to the angular speed at which the vehicle turns, and both change sign with that of the turning motion. Hence the compensation is correct for all speeds of turning.

This type of stabiliser when fitted with special erectors, a simple example of which was described, supplies a complete solution of the vertical problem. Assuming an error made (small) in adjusting the compensating component of spin the resting position of the device is one in which it is inclined to the true vertical at a very small angle. The devices solve the problem completely for the rapid and slow-turning movements of aeroplanes, and for the turning motions of ships.

Discussion.—Sir James Henderson, after complimenting Professor Gray on his lecture, referred to the great difficulties of the problem. These difficulties vary with the accuracy aimed at. If it be only required to maintain the vertical within one degree the problem is very easy, but if it be required to maintain it within 1 minute of arc the difficulties are very great, almost if not quite unsurmountable. The difficulties increase almost as the square of the accuracy aimed at.

Professor Gray had concentrated upon the problem of the bomb-dropping sight for aircraft, and had achieved considerable success during the war. The practical accuracy then aimed at in this connection was to maintain the vertical to about ¼ deg., and to this degree of accuracy Professor Gray had attained, as stated in his lecture.

The accuracy of any instrument of this type could be calculated accurately if the method of control were continuous. In Professor Gray's instrument the method of control involves a discontinuity which does not lend itself to easy computation. There are other methods of control, however, which are continuous and which enable accurate calculations to be made.

Professor Gray had said nothing in his lecture to give any idea of the amount of damping he employed. This determines the accuracy, because if the damping be very great the gyro follows the virtual vertical at corresponding rates and the deviation increases accordingly. On the other hand, if the damping be greatly diminished a considerable deviation arises from the rotation of the earth and a connection to the gyro-compass is required to compensate it. Thus when great accuracy is required the problem becomes excessively difficult.

Professor Gray's method of eliminating the effects of the centrifugal force during a turn was ingenious. If the speed adjustment be perfect, then any deviation which the pendulum has relatively to the vertical at the beginning of the turn turns in azimuth with the plane. The deviations due to any change of velocity either fore or aft or during a turn are, however, not so easily compensated.

M. Paul Schilowsky said that naval experts ask for a degree of accuracy which must be the despair of gyroscopic inventors, but accuracy to a degree or half a degree of angle is by no means unattainable. He had tried a different solution from that given by the lecturer, viz., that of suspending the gyroscopic pendulum in neutral equilibrium on knife-edges passing through its centre of gravity. In time, however, precession takes place with this arrangement, and the pendulum errs progressively from the true vertical. What is required is that the pendular suspension should be neutral for curved motion but stable for rectilinear motion. Sir James Henderson had designed an instrument for indicating the curvature of the path of the aeroplane. A combination of the two devices should make it possible to meet the requirement mentioned. The lecturer's plan was open to the objection that very rapid changes of rotary speed in the gyroscope would be necessary to compensate for the rapidity with which an aeroplane changes its linear speed. His admiration for the lecturer's work was sincere, and he should expect great results if the latter would take up the problem of altering the suspension of the gyroscope according to the curvature of the path.

Mr. T. Smith said that all present would have followed the lecture with the greatest interest. It was not easy, however, for those less familiar than the lecturer with the practical handling of gyroscopic apparatus to appreciate all the points at issue in the absence of a formal mathematical treatment. Possibly mathematical difficulties would arise from the discontinuities which had been mentioned by Sir James Henderson, but the modern methods for dealing with discontinuous quantities developed in connection with the quantum theory might perhaps give a hint as to the line of attack to be adopted in the present case.

The lecturer, in reply to the discussion, dwelt mainly on the point raised by M. Schilowsky, and claimed that his apparatus did become automatically "blind" during curved motion of the aeroplane in a manner satisfying M. Schilowsky's requirement. The effect of the earth's rotation on the gyroscope is very small provided the precessional period is long. The president congratulated the lecturer on his solution of an important and difficult problem, and proposed a vote of thanks, which was carried with acclamation.

National Gas Exhibition, 1923.—An exhibition of apparatus to demonstrate the uses of gas for domestic and industrial purposes will be held in the Bingley Hall, Birmingham, from September 17 to October 3 next, under the presidency of the Lord Mayor of that City. The last three days of the exhibition will coincide with the annual conference of the British Commercial Gas Association in Birmingham, and other meetings of interest to those engaged in the gas industry are being arranged to take place during the period of the exhibition. The support of the Institution of Gas Engineers and all the leading associations in the trade is being given to the enterprise which it is hoped will be of benefit equally to users and manufacturers of gas apparatus and machinery. The exhibition director is Mr. Charles Stanley, of 27, Paradise Street, Birmingham.

Kelly's Directory of Merchants, Manufacturers and Shippers of the World, 1923.—The thirty-sixth annual edition of Kelly's Directory differs from its predecessors mainly in the section dealing with Canada. In the previous editions the Provinces of that Dominion were arranged alphabetically with an alphabetical list of the towns for each province. The development of Canada has, however, made it impossible even for those familiar with the country to recollect with certainty the province in which certain towns are situated. To facilitate reference therefore the whole of the Canadian towns are now arranged in one alphabetical list, with a notification of the province opposite each. The Directory is in two volumes containing some 5,000 pages, giving information concerning 20,000 foreign and colonial towns throughout the civilised world. The first volume deals with foreign countries and their dependencies, and the second with Great Britain, her dominions and possessions. The index is in four languages. The work is published by Kelly's Directories Limited, of 186, Strand, London, W.C. 2, at the price of 64*s.*, post free.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The uneven character of conditions in the engineering and machinery trades becomes more accentuated week by week. A few firms possessing the most up-to-date equipment and having expert selling organisations are working virtually at full pressure, but in a general sense business is a long way below production capacity, and, in face of dear fuel and heavy rates and taxes, makes but slow headway. The recent boom in mild steel appears to be on the wane. Furnaces in the South Yorkshire and adjoining districts are producing an output in excess of the pre-war average, but contracts are not being renewed at the rate at which they are expiring. The past month has witnessed something in the nature of a strike of buyers against the high prices ruling. This, in conjunction with the restitution of Continental competition on a small scale, has reacted on official quotations, which, with the exception of that applying to hard basic steel, have during the past week been revised in a downward direction. The biggest cut is in soft basic billets, which are 1*l.* per ton lower than a month ago. Hematites have declined on an average 3*s.* 6*d.* per ton, Lincolnshire forge and foundry iron and Derbyshire forge iron are each 2*s.* 6*d.* per ton easier, and there is a reduction of 1*s.* 3*d.* per ton in the price of Derbyshire No. 3 foundry, bars have eased 5*s.* and sheets 10*s.* per ton. The revised rates are as follow:—Hard basic steel billets, 11*l.*; soft basic steel billets, 9*l.*; West Coast hematites, 6*l.* 10*s.*; East Coast hematites, 6*l.*; Lincolnshire No. 3 foundry, 5*l.* 10*s.*; Lincolnshire forge, 5*l.* 5*s.*; Derbyshire No. 3 foundry, 5*l.* 7*s.* 6*d.*; Derbyshire forge, 5*l.* 2*s.* 6*d.*; bars, 12*l.* 10*s.*; and sheets, 15*l.* The output of acid steel is on an improved scale, but orders for crucible qualities are still a long way below production capacity. There is an expanding demand for manganese specialities for railway construction. Another stain-resisting alloy has been jointly produced by Mr. Etchells, co-inventor of the Greaves Etchells furnace, and Mr. A. Popplewell, a local manufacturer. The alloy is said to be equally suitable for the manufacture of engineering parts and as a substitute for articles usually made of electro-plate. It is being marketed in the form of cutlery blanks. Orders for wheels, axles and tyres have been placed by India and Australia, and South American users are in the market for wagon parts. Home business in railway materials is unaccountably retarded. Revival in the tool trades is hampered by the further release of Government stocks at cheap rates. Excavating tools, axes, spades and shovels are on order for Australia, South Africa, and Ireland, and milling cutters, taps and dies for Belgium, Sweden and Holland. South America is taking an increased tonnage of files and rasps. Electrical fittings and apparatus are an improved market.

South Yorkshire Coal Trade.—A renewal of export inquiries has strengthened the colliery position, and has checked a slight tendency to weakness in the principal brands. Except in the case of house coal, the pits are readily disposing of the whole of their output on contract account. Best steams are firmly held at maximum rates. Cobbles and nuts are, if anything, a shade stronger, and slacks on the week have appreciated 6*d.* The market for coke is less robust, but as home consumers quite readily absorb any surplus left from export requirements, prices are quotably unaltered. Gas cokes are only moderately firm. Quotations:—Best branch handpicked 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house coal, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 18*s.* to 21*s.*; Yorkshire hards, 22*s.* to 24*s*; Derbyshire hards, 21*s.* to 24*s.*; rough slacks, 12*s.* to 14*s.*; nutty slacks, 11*s.* to 13*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Inactivity continues to characterise the Cleveland pig-iron market. Buyers generally are very backward and not disposed to negotiate except for early essential needs, though a little forward buying is understood to have occurred at below current rates. Demand is no longer sufficient to absorb output with the result that stocks, though as yet not at all heavy, are steadily accumulating at makers' yards. Quotations have been further reduced, but the moment has not attracted buying to any extent. No. 1 is 126*s.*, No. 3 g.m.b. 115*s.*, No. 4 foundry 112*s.* 6*d.*, and No. 4 forge 110*s.*—all f.o.t. makers' works, or f.o.b. Tees.

Hematite.—East Coast hematite is little sought after just now, customers holding off in anticipation of still further fall in values. This week's drop lowers the price of mixed Nos. to 114*s.*, both for home purposes and for shipment abroad. Possibly even the price named could be shaded.

Foreign Ore.—So far as is ascertainable there is absolutely nothing doing in foreign ore. Nominally best rubio is 24*s.* c.i.f. Tees.

Blast-furnace Coke.—Notwithstanding its continued scarcity Durham blast-furnace coke is easier, but prices are still much higher than consumers consider they should be. The concession quotation to local regular customers is in the neighbourhood of 42*s.* delivered.

Manufactured Iron and Steel.—Demand for finished iron and steel is very quiet, and the boilermakers' dispute is still holding up specifications for shipbuilding material. Whilst generally the accounts given by manufacturers are gloomy it is gratifying to learn that Messrs. Dorman, Long and Co., intend to restart their Clarence Steelworks next week. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing

(tapered), 11*l.* 10*s.*; steel billets (soft), 10*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 10*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets, 18*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Movement in the steel trade of Scotland continues to be confined within very narrow limits and the position is practically unchanged this week. The general trade of the country as a whole is not good, with the result that consumers of steel material have no occasion to buy freely and are still purchasing no more than is actually necessary. Makers are faced with a very awkward position in the near future unless the outlook becomes a little better, as orders now on hand cannot be made to spin out indefinitely. Although the demand is small it is of a general character, and structural sections and black sheets are perhaps accounting for a fairish proportion of to-day's output. Prices have an easier tendency, but even a reduction could hardly be expected to give a stimulus of any great moment to business.

Malleable Iron Trade.—In the West of Scotland malleable iron trade there has been little change in the conditions. Production is more than equal to demand, and even inquiries show a falling-off. The steel re-rolling branches are doing fairly well still, but even there the prospects are not so bright.

Scottish Pig-Iron Trade.—A very dull tone pervades the Scottish pig-iron market, and makers are not booking contracts of any great consequence at present. Dealings are very limited and old contracts are responsible for most of the current business. Prices are all easier, and the downward tendency continues both in hematite and foundry sorts.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, June 16, totalled 791 tons. Of that quantity 710 tons went foreign and 81 tons coastwise. For the corresponding week last year the figures were 335½ tons foreign and 101½ tons coastwise, a total of 437 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—As usual a number of resolutions were adopted at the annual conference of the South Wales Miners' Federation held at Cardiff this week. The most important of these was one that three months' notice be tendered as early as possible to terminate the present agreement, another suggested that membership of the Federation be made a qualification for employment in or about the mines, and another that in order to avoid the continual stoppage of collieries owing to non-unionists the owners should be approached with a view to an agreement being entered into confining the benefits of the Conciliation Boards to persons who are members of the Federation. The balance sheet of the Federation for 1922 which was presented to the meeting showed that the income amounted to only 70,536*l.* compared with 282,235*l.* in 1921, and that the expenditure was 43,992*l.* against 301,295*l.*, so that there was a surplus of 26,544*l.* against a deficit of 19,060*l.* in 1921. The decreased income was due to a decline of 30,530 in membership, and the drop in expenditure to the fact that nothing was paid out in strike, lock-out or out-of-work pay last year. Business on the coal market was again inactive last week and prices for steam coals continued to decline, but those for anthracites remained strong. Buyers generally adopted a mark-time policy, and though collieries were fairly well placed with contract commitments the amount of fresh business available was insufficient to absorb surplus outputs, and consequently values became a matter of individual circumstances and rapidly declined. The change that has taken place in prices as compared with a month ago will be gathered from the following:—

	May 19.	June 19.
Best Admiralty large	42*s.* 6*d.* to 45*s.*	32*s.* 6*d.* to 35*s.*
Best dry large ...	38*s.* to 40*s.*	33*s.* to 34*s.*
Monmouthshire large	37*s.* 6*d.* to 41*s.*	30*s.* to 32*s.* 6*d.*
Best steam smalls	32*s.* 6*d.* to 33*s.*	24*s.* to 25*s.*
Inferior smalls ...	20*s.* to 27*s.* 6*d.*	17*s.* to 21*s.*
No. 2 Rhondda large	34*s.* to 36*s.*	27*s.* 6*d.* to 28*s.* 6*d.*
Throughs ...	31*s.* to 35*s.*	26*s.* to 28*s.*
Big Vein Anthracite large ...	47*s.* 6*d.* to 50*s.*	52*s.* 6*d.* to 55*s.*
Paris Nuts ...	55*s.* to 57*s.* 6*d.*	60*s.* to 62*s.* 6*d.*
Rubbly Culm ...	17*s.* to 17*s.* 9*d.*	17*s.* 6*d.* to 18*s.* 6*d.*
Breaker Duff ...	12*s.* 6*s.* to 13*s.*	13*s.* to 13*s.* 6*d.*
Billy Duff ...	10*s.* 6*d.* to 11*s.*	11*s.* to 12*s.*
Patent fuel ...	40*s.* to 43*s.* 6*d.*	37*s.* 6*d.* to 39*s.*
Coke-foundry ...	65*s.* to 70*s.*	55*s.* to 60*s.*

Steam coal prices, it will be seen, have declined by 4*s.* to 10*s.* per ton and those of anthracites have increased by 6*d.* to 5*s.* per ton.

Iron and Steel.—Exports of iron and steel goods from South Wales last week amounted to 15,817 tons, or 5,000 tons less than in the previous week. Of the total, 9,844 tons comprised tinplates and terneplates compared with 9,122 tons, blackplates and sheets, 2,691 tons against 2,340 tons; galvanised sheets, 1,770 tons against 2,810 tons; and other iron and steel goods to 1,506 tons against 6,573 tons.

NOTICES OF MEETINGS.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, June 25, at 8 p.m., at the Engineers' Club, Coventry-street, W. 1. Address by Dr. W. C. Geer, on "Some American Rubber Manufacturing Problems."

THE INTERNATIONAL AIR CONGRESS.—Monday, June 25 to Saturday, June 30, at the Institution of Civil Engineers, at Great George Street, S.W. 1. Monday, June 25, at 10.45 a.m. Opening of the Congress by His Royal Highness The Prince of Wales. Inaugural Address by His Grace The Duke of Sutherland. Group A, Lecture Theatre, at 11.45 a.m.: "Standardisation of Methods of Research," by Sir R. T. Glazebrook; "Proposal for Standardisation of the Methods of Computing Wing Sections," by M. A. G. von Baumhauer; "Standardisation de la Notation Mathématique de l'Aéronautique," by Commandant Herrera. Council Room. "Les Alliages Ultra-Légers en Aéronautique," by Messrs. A. M. Portevin and R. de Fleury. Committee Room. "Note sur la Détermination de l'Indice de l'Essai Statique des Avions de Transport," by M. L. Breguet; "Les Enquêtes sur les Accidents d'Aviation, les Enseignements à en Tirer," by M. F. Devaluez. Group B, Reading Room: "Air-screw Research in Great Britain," by Dr. H. C. Watts. Monday afternoon, at 3 p.m. Group A, Lecture Theatre: "Slotted Wings," by Mr. F. Handley Page; "Apparatus and Equipment Recently Constructed in the Aerodynamic Department, National Physical Laboratory," by Mr. R. V. Southwell. Reading Room. "Aircraft Standardisation," by Mr. C. le Maistre; "L'Unification et les Produits Standards dans l'Aéronautique," by Col. C. Grard. Group C, Council Room: "Affichages des Renseignements Météorologiques dans les Aérodromes," by Col. Delcambre; "Some Technical Problems and Experiences Concerning Winter Flying," by Ing. T. Angström; "Organisation du Balisage Lumineux Nocturne," by Capt. E. Marcotte. Committee Room. "De l'Etablissement du Droit International Privé de l'Air," by M. E. Sudre; "The International Air Convention—Scandinavian Points of View," by Prof. Engstromer; "Suggested Minor Alterations in the I.A.C.," by Capt. Lubeck; "The Marking of Aircraft," by Lieut. Hj. Riiser-Larsen. Tuesday, June 26. Various Visits and Excursions. Wednesday, June 27, at 10 a.m. Group A, Reading Room, at 10 a.m.: "Fundamentals of Fluid Motion in Relation to Aeronautics," by Prof. L. Bairstow; "Some Aspects of Modern Aerofoil Theory," by Mr. H. Glauert; "The Circulation Theory of Lift," by Major A. R. Low; "Sur la Résistance des Fluides," by Dr. D. Riabouchinsky. Group B, Council Room: "A Survey of Recent Work Carried Out in the Research and Experimental Department of the R.A.E.," by Wing Commander Hynes; "The Crude Oil Aero Engine," by Mr. A. E. L. Chorlton; "Some Problems of Static Radial Air-Cooled Aero Engines," by Mr. A. H. R. Fedden. Group C, Committee Room: "Le Nouveau Laboratoire à Dépression Atmosphérique et à Basse Température du Bourget," by Dr. G. Garsaux. Lecture Theatre, "Air Mails," by Brig.-General F. H. Williamson; "Transport du Courrier," by Jonkheer van Heemstede; "The Development of Commercial Aviation," by Mr. F. Handley Page"; "Commercial Aircraft and the State," by Col. C. L'Estrange Malone. Wednesday afternoon, at 2.30 p.m. Group A, Lecture Theatre: "The Technical Development of the Aeroplane," by Mr. J. D. North; "Testing of Aircraft Structures and Components," by Mr. W. D. Douglas; "The Stability of Oscillations of An Aeroplane Wing," by Messrs. A. G. von Baumhauer and C. Koning. Reading Room: "Control at Low Speeds," by Mr. R. McK. Wood; "Experimental Determination of Aircraft Stability," by Major T. M. Barlow"; "Longitudinal Stability, Controllability and Manœuvrability of Aeroplanes," by Prof. E. P. Warner. Group B, Council Room: "The Development of Aero Engine Materials," by Dr. L. Aitchison; "Researches on the Alcohol Internal Combustion Engine Problem," by Prof. E. Hubendick. Group C, Committee Room: "La Navigation Aérienne en France; Les Méthodes Actuelles et ses Applications en Particulier à la Photographie," by Capt. Volmerange; "Navigation Equipment for Long Distance Flights," by Major Wimperis; "L'Emploi des Méthodes de Navigation est Indispensable au Succes des Transports Aériens Commerciaux," by M. A. B. Duval. Thursday, June 28. Various Visits and Excursions. Friday, June 29, at 10 a.m. Group A, Lecture Theatre: "Reliability of Model Data," by Mr. R. McK. Wood; "Méthode d'Expérimentation et Utilisation des Resultats Obtenus sur Modéles," by Col. Robert. Reading Room: "Aviation Insurance," by Mr. A. L. Sturge; "The Design of Commercial Aircraft," by Major R. H. Mayo. Group B, Council Room: "The Nature of Lubricants in Engineering Practice," by Dr. T. E. Stanton; "Some Physical Properties of Lubricants," by Mr. A. E. Evans; "Viscosity of Lubricants at High Temperature and Pressures, by Mr. M. D. Hersey. Group D, Committee Room: "The Commercial Aspect of Airship Transport," by Major G. H. Scott; "The Hulls of Rigid Airships," by Lieut Col. V. C. Richmond. Friday afternoon, at 2.30 p.m., Group A., Lecture Theatre: "Note sur la Résolution Graphique des Equations du vol Horizontal," by Commandant Alayrac; "Méthode Graphique Permettant le Trace d'Ailes d'Avions," by M. E. Royer; "Note sur le Calcul des Ailes d'un Avion," by Prof. Mirea; "The de Bothezat Helicopter," by Prof. de Bothezat. Group B., Council Room: "Aviation Spirit—Past and Present and Future," by Dr. A. S. Dunstan and Dr. F. B. Thole; "Les Carburants et l'Industrie des Lignites," by Capt. E. Marcotte. Group C. Reading Room: "Aerial Surveying," by Prof. B. Melvill Jones; "Aerial Navigation and Japan," by Major W. Jikemura. Group D, Committee Room: "Recent Progress in Airship Construction in Italy," by Ing. M. Nobile; "The Effect of Bow Stiffeners in Non-Rigid Airships," by Professor E. P. Warner. Saturday, June 30, at 10 a.m., in the Great Hall. Concluding meeting.

THE INSTITUTION OF GAS ENGINEERS.—Tuesday, June 26, to Thursday, June 28. Annual General Meeting at the City Hall, Belfast. Tuesday, June 26, at 10.30 a.m.: Presidential Address. "Eighth Report of the Gas Investigation Committee 'Fairweather' Recording Calorimeter"; "Ninth Report of the Gas Investigation Committee. Aeration in Atmospheric Burners." Wednesday, June 27, at 10.30 a.m.: "The Flow of Gas in Pipes," by Mr. Stephen Lacey; "Tenth Report of the Gas Investigation Committee. Further Examination of the Blue and Carburetted Water Gas Processes"; Report of the Institution Gas Fellowship, "The Gasification of Coke in Steam, with Special Reference to Nitrogen and Sulphur," by Mr. Stuart Pexton, M.Sc., and Mr. J. W. Cobb, B.Sc., F.I.C. Wednesday evening, at 8 p.m.: Lecture on "The Flow of Gas," by Professor W. B. Morton, M.A. Thursday, June 28, at 10.30 a.m.: "Distribution in Belfast," by Mr. A. M'I. Cleland; "Ammonia Yields from Vertical Retorts," by Mr. George Braidwood; "Report of Refractory Materials Committee," introduced by Mr. A. E. Broadberry, "(*a*) Refractories under Load," "(*b*) Fortifying Refractories with Sillimanite," (*c*) Carbonised Clays," (*d*) Is the Purification of Fireclays Worth While?"; "Report of the Life of Gas Meters Committee."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Summer Meeting, Tuesday June 26, to Friday, June 29, at the Royal Technical College, Glasgow. Tuesday, June 26, at 10.30 a.m.: Reading and discussion of papers; afternoon visits to various works. At 8 p.m., Conversazione in the City Chambers. Wednesday, June 27, at 10 a.m.: Reading and discussion of papers. Afternoon visits to various works. At 7.30 p.m.: Institution Dinner at the Grosvenor Restaurant. Thursday, June 28: Alternative whole-day excursions. Friday, June 29: Alternative whole-day excursions. Papers to be read and discussed at the two morning meetings: "Water-Tube Boiler and Crane Construction," by Sir James H. R. Kemnal, F.R.S.E.; "Modern Dock Appliances at Glasgow Harbour, including the Handling of Grain in Bulk and Dredging Plant," by Mr. D. Fife.; "Sugar Machinery," by Lord Invernairn; "Clyde Marine Oil Engines," by Professor A. L. Mellanby, D.Sc.; "Improvements in Mechanical Contrivances in Connection with the Storage and Distribution of Water," by Mr. E. Bruce Ball.

"THE SHIPYARD."—This is the title of the works magazine issued by Messrs. Swan, Hunter & Wigham Richardson, Limited, and Barclay, Curle & Co., Limited. The issue for June, No. 53, volume V, contains a series of interesting notes on shipbuilding, and an article entitled "Our Shipyards" showing the capacity of this important British shipbuilding concern.

THE INSTITUTE OF PETROLEUM TECHNOLOGISTS.—We are requested to state that on and after Monday, June 25, 1923, the address of the Institution of Petroleum Technologists will be: Aldine House, Bedford Street, Strand, W.C. 2. The offices of the Institution will be officially closed from 5 p.m. Wednesday, June 20, 1923, till 10 a.m. Wednesday, June 27, 1923, to enable the change to be carried out.

THE KAYE SEAMLESS STEEL OILCAN.—We have received from Messrs. Joseph Kaye & Sons, Limited, of Lock Works, Leeds, a sample oil-can of their latest pattern. The body of the oilcan, which holds one pint, is pressed from a single piece of stout sheet steel, and the handle and spout are of unusually strong design. The large filling hole in the top of the body is closed by an oil-tight sliding door, and a perforated strainer below the door prevents the access of waste or other foreign material to the interior of the can. The oil can is one which appears capable of standing without injury the roughest usage to which such things are liable.

NATIONAL ENGINEERS' ASSOCIATION.—At the invitation of the Brush Electrical Engineering Company, Limited, Loughborough, a party of members of the National Engineers' Association visited the Falcon Works, Loughborough, on Saturday, the 9th inst. The party included a number of textile mill engineers from Manchester and district and a number of works engineers from Leicester. The Brush Company's electrical motors and equipment designed specially for use in textile mills, and the modern machinery installed for their manufacture, and the Brush-Ljungstrom turbine, greatly interested the visitors.

THE BIRMINGHAM ELECTRICITY UNDERTAKING.—During the year ending March 31 last, the City of Birmingham Electric Supply Department sold 139,468,153 units of electrical energy, of which practically 30,000,000 units were used for traction and the remainder for light and power. The average price obtained was 1·797*d.* per kilowatt-hour, as compared with 2·252*d.* per kilowatt-hour for the previous year. Notwithstanding this reduction in price, the gross profit of the department has increased from 316,802*l.* to 474,581*l.*, and a contribution of 12,500*l.* has been made to the rates, after setting aside 127,759*l.* as reserve and 102,234*l.* to a renewals fund. The total lighting connections are equivalent to 474,730 60-watt lamps and the motor connections aggregate 173,127 h.p. In spite of adverse trade conditions, the results of the undertaking both in output and profits are decidedly better than for the previous year, and Mr. R. A. Chattock, the city electrical engineer, and his staff, deserve credit for them. When the new station at Nechells is brought more largely into use, still further improvements are likely to be shown.

THE CARPET WORKS OF MESSRS. JAMES TEMPLETON AND CO., GLASGOW.

(*For Description, see Page* 768).

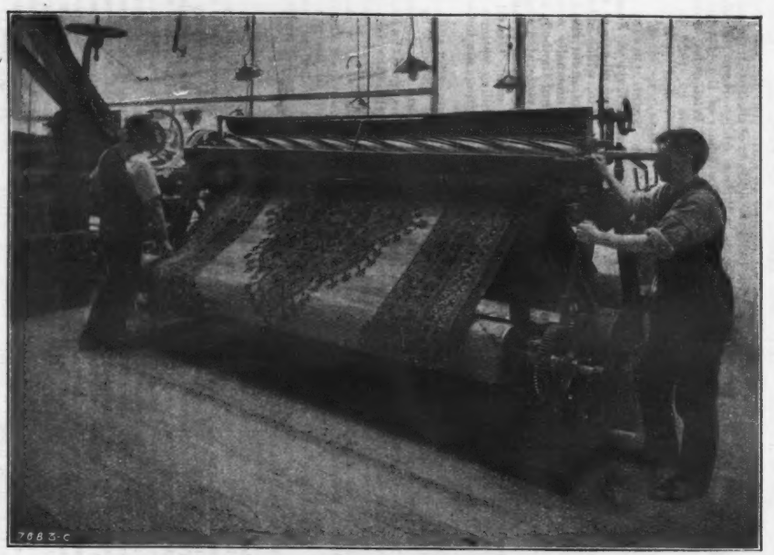


Fig. 4. Carpet Cropping Machine.

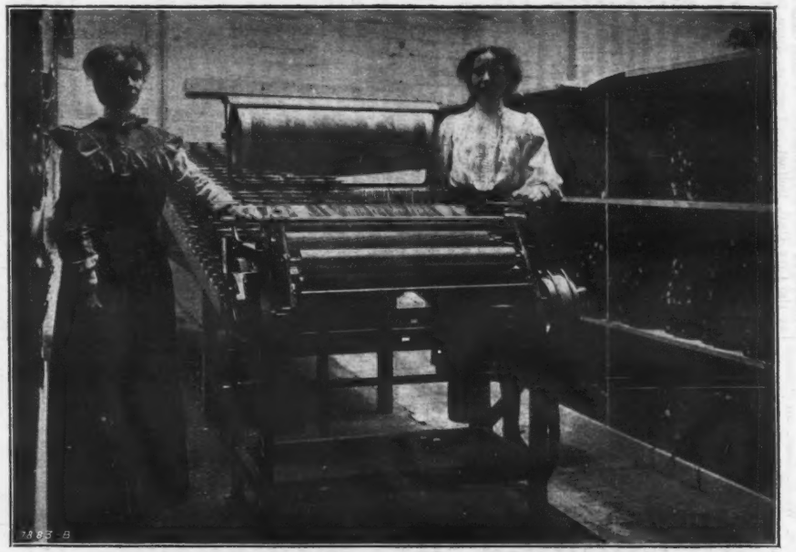


Fig. 5. Spooling Frame for Imperial Axminster Carpets.

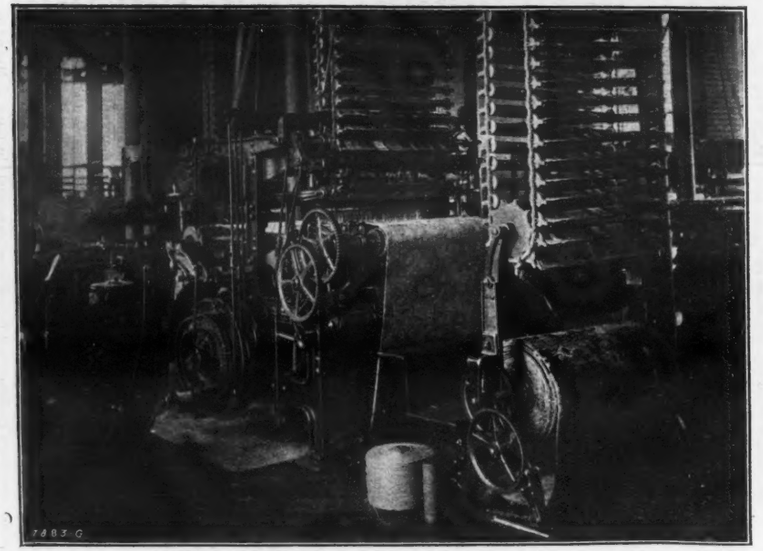


Fig. 6. Loom for Imperial Axminster Carpets.

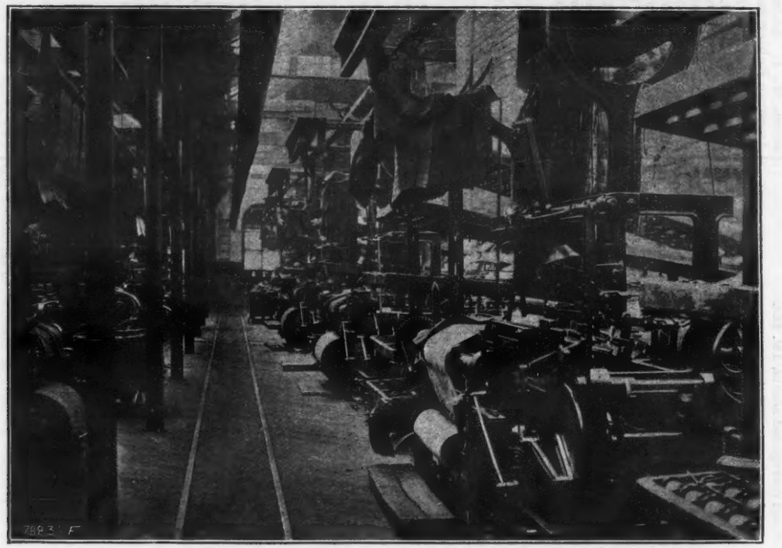


Fig. 7. Jacquard Looms for Brussels and Wilton Carpets.

Fig. 6. Loom for Imperial Axminster Carpets.

Fig. 7. Jacquard Looms for Brussels and Wilton Carpets.

SULPHATE OF AMMONIA PLANT AT THE PROVAN CHE

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Fig. 2 OUTSIDE ELEVATION

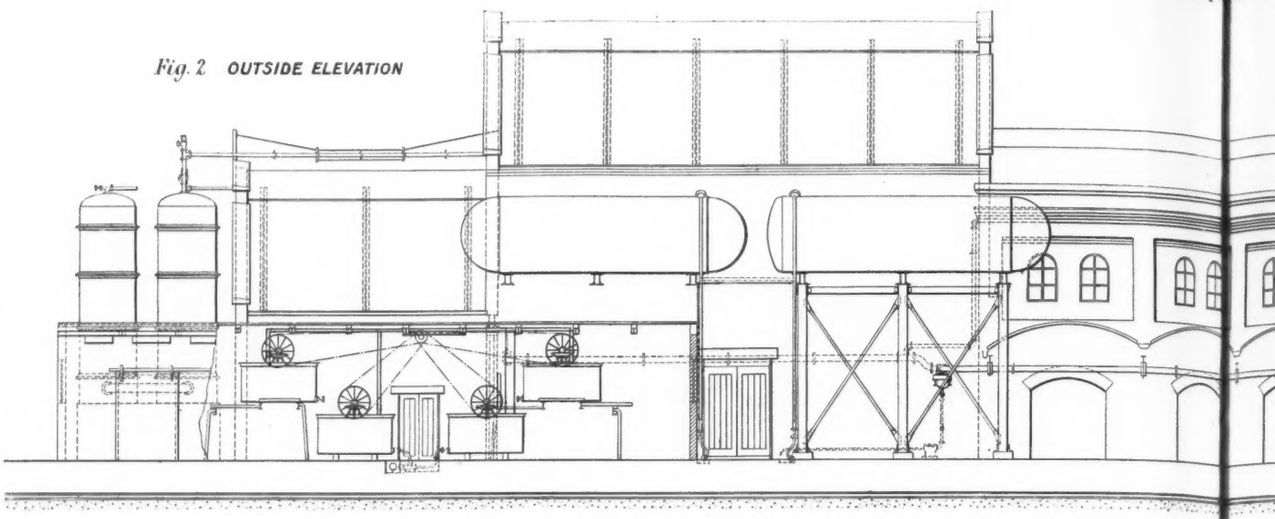


Fig. 3 ELEVATION ON A.A.

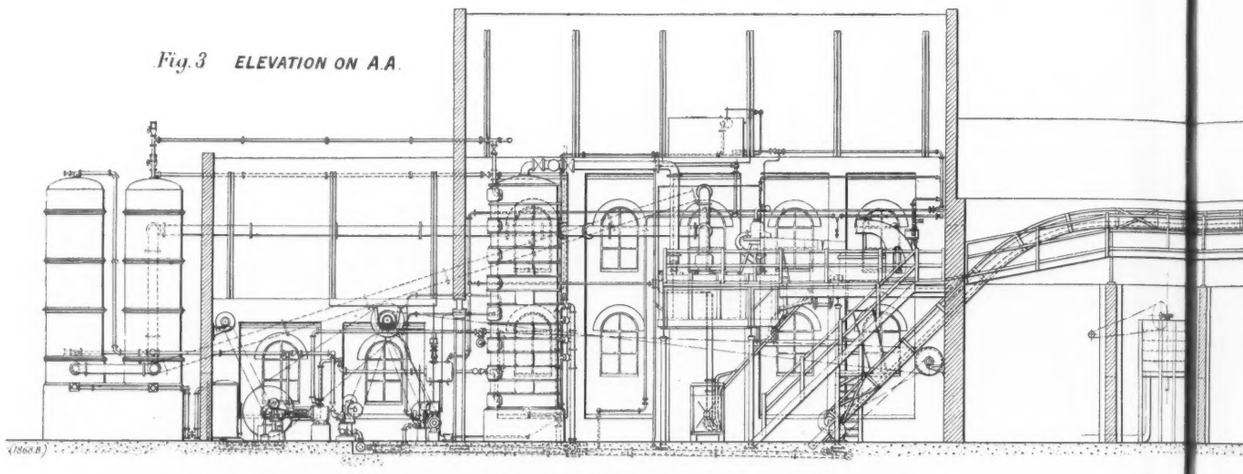
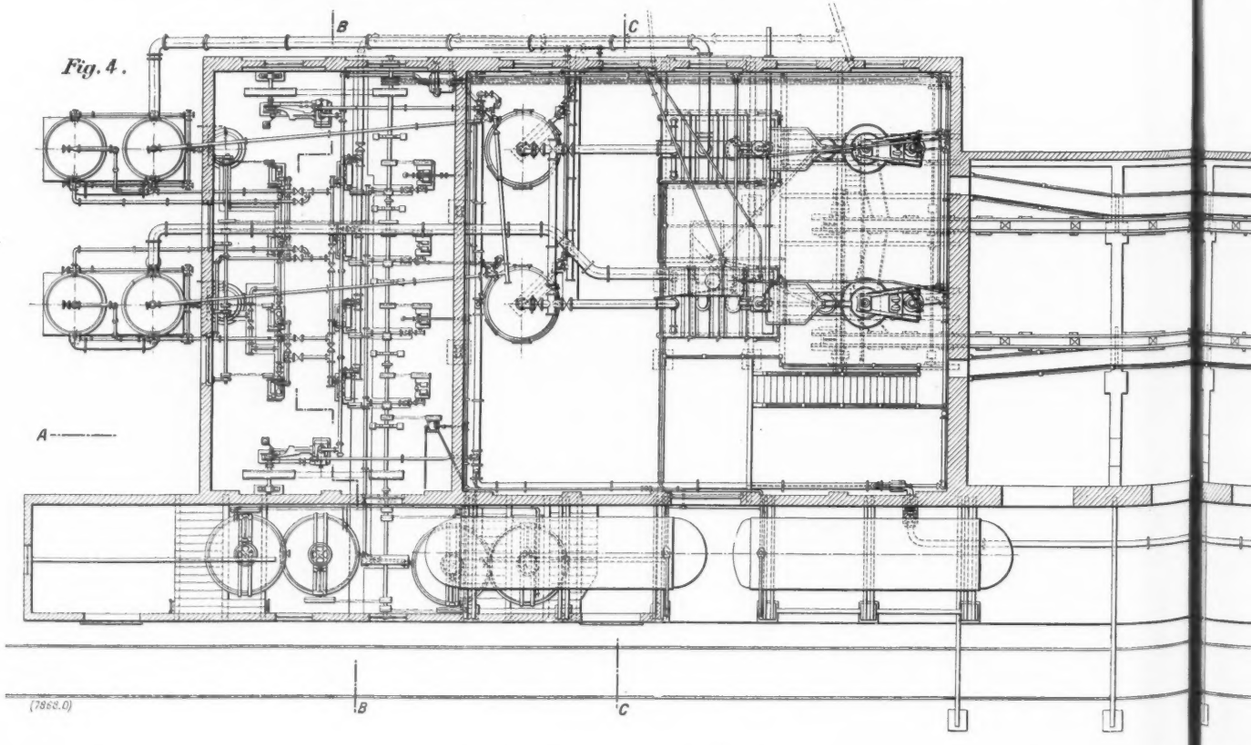


Fig. 4.



OVAN CHEMICAL WORKS OF THE GLASGOW CORPORATION.

(For Description see Page 761.)

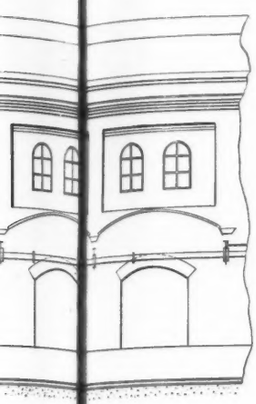
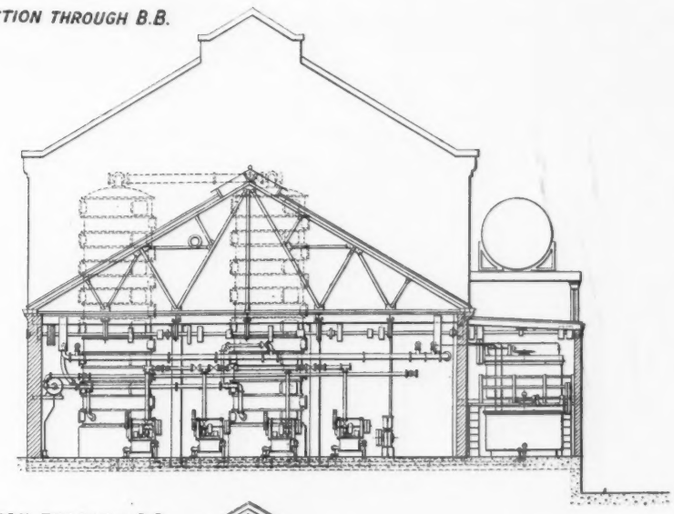


Fig. 5. SECTION THROUGH B.B.



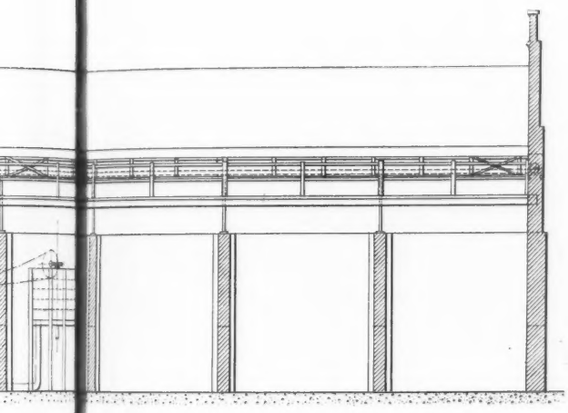
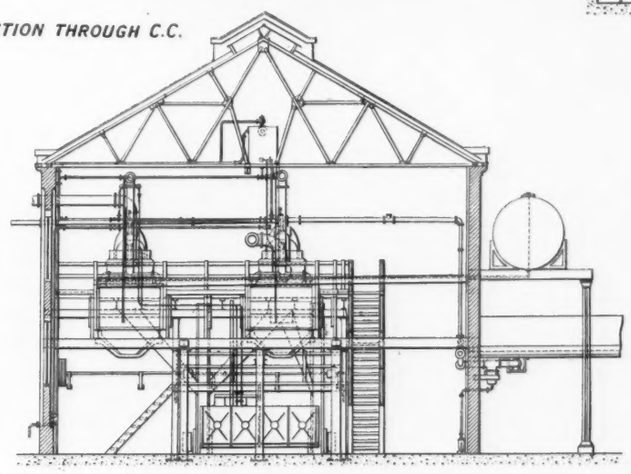


Fig. 6 SECTION THROUGH C.C.



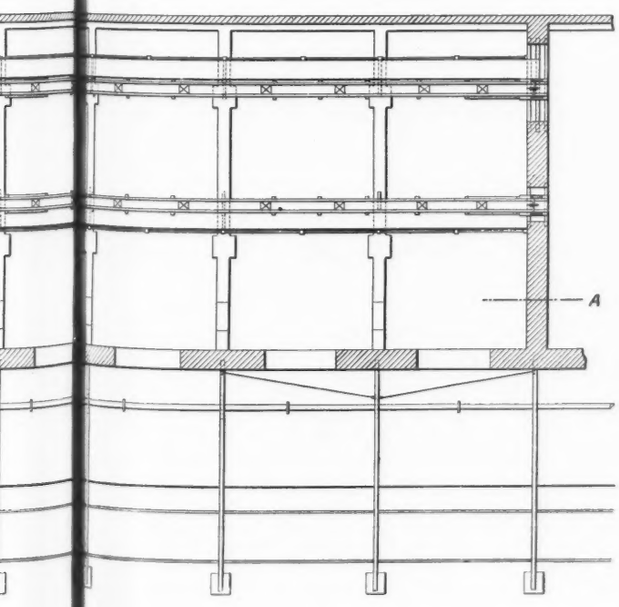
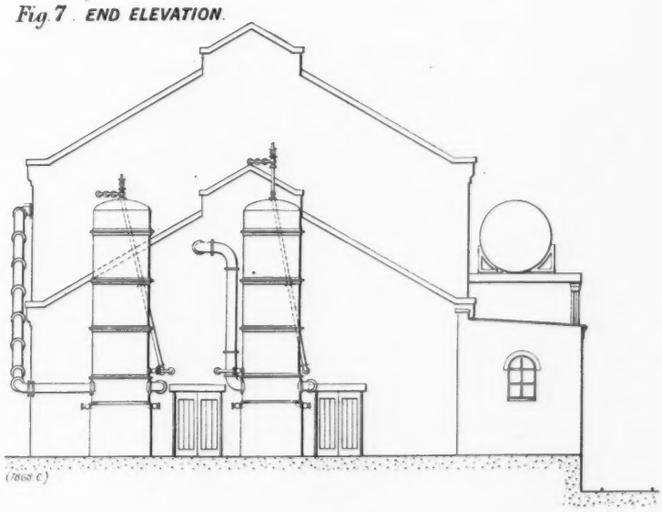


Fig. 7. END ELEVATION.



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Two-Page Plate.—SULPHATE OF AMMONIA PLANT AT THE PROVAN CHEMICAL WORKS OF THE GLASGOW CORPORATION.

ENGINEERING.

FRIDAY, JUNE 22, 1923.

THE USE OF STEAM AT EXTREMELY HIGH PRESSURES.

THE value of steam as a means of transforming heat into work lies in the comparatively large amount of heat energy which can be transferred from the furnace to the engine by every pound of the working fluid without involving pressures or temperatures greater than ordinary constructional materials will stand. Practical considerations for many years limited steam pressures to a maximum of about 200 lb. per square inch, but with the improvements in materials and the development of manufacturing methods, a decided tendency has been evident during recent years to operate boilers at higher and higher pressures. A steam pressure of 350 lb. per square inch is not regarded to-day as anything exceptionally high for a large power plant and about 500 lb. per square inch is already in use in this country. There are two main reasons for this tendency to increase pressures. One is the desire to secure a greater thermodynamic efficiency of the plant, and the other is the appreciation of the practical benefits of the reduction in the size of steam pipes which the higher pressures render possible. The latter reason is of considerable importance, for when a single turbo-generator may require as much as 150 tons of steam per hour, the less the volume of the steam, so long as boiler drums, pipes and joints will stand, the better. As to efficiency, the theoretical increase with increase of pressure is not very great, and the overall thermal efficiency attained by such a station as Radcliffe, for example, with steam at only 160 lb. pressure, might well be envied by many stations working at nearly double the pressure.

The same reasons which have caused engineers to increase steam pressures to those which are being adopted in modern power-plants are impelling them to consider the employment of higher pressures still. It is officially reported that the Edison Illuminating Company of Boston, U.S.A., are arranging for the installation of a boiler and turbine to work at 1,200 lb. per sq. in. The turbine will be rated at 2,000 kw., and will exhaust at a pressure of 375 lbs., the steam, after re-heating being passed on to the main turbine. A good deal has been heard recently of a Swedish design of boiler to generate steam at 1,500 lb. per square inch. The inventor keeps the steam-raising elements in continuous rotation, the idea being that the water shall be held against their internal surfaces by centrifugal force. The centrifugal pressure of the water would tend to keep the heated metal surfaces thoroughly wetted and free from bubbles, while the inner surface of the water-layer would allow of the free escape of the steam made at all points along the element. Apart altogether from the obvious mechanical difficulties which have to be overcome, it is questionable whether the avoidance of turbulence of the water is altogether a good thing for heat transmission, and furthermore one would imagine that the need for the elimination of steam bubbles in contact with the walls would be diminished rather than increased with very high pressures on account of the correspondingly reduced size of the bubbles. Whether the complications inherent in a boiler of this type are justified, or whether the inventor has introduced them as a safeguard against less serious or even imaginary troubles we cannot say, but whatever the outcome of the design the departure from ordinary practice will do good by the establishment of facts.

The generator of steam at excessive pressures is bound to give rise to problems in boiler construction and maintenance which may not be easy to solve, and the question obviously arises as to what compensating advantages in efficiency may be hoped for. The value of a pound of steam is, of course, by no means proportional to its pressure, but only to the amount of its heat which can be transformed into work by expansion to some lower pressure. Since the publication of the steam tables and equations of Professor Callendar, engineers have had reliable means for computations on the properties and characteristics of steam at all pressures and temperatures. Taking 0·5 lb. absolute, or a vacuum of about 29 in., as the lowest practical exhaust pressure, a pound of dry steam at 500 lb. pressure, if used in an ideally perfect engine will only do 15 per cent. more work than the same weight of steam at 200 lb. pressure, used under the same conditions. The proportion of the heat supplied to the steam which can theoretically be turned into work is 35·3 per cent. in the former case and 31·96 per cent. in the latter, so that the gain either in work or efficiency due to the higher pressure is not very great. If we push the initial pressure still higher, say to 2,400 lb. per square inch, much the same result is obtained. The available work per pound, calculated from Callendar's tables, is 261·16 pound-centigrade units, or only 27·05 per cent. more than in a pound of steam at 200 lb. pressure, and the thermodynamic efficiency of a perfect engine using steam even at this extremely high pressure would not exceed 41·78 per cent.

So far we have been considering steam in the dry saturated condition, but in practice, of course, greater efficiency is sought by superheating it to the highest temperature which practical considerations permit. This may be taken, at present, as about 700 deg. F. In order to avoid interpolation and to take advantage of the greater convenience of the Centigrade scale, we will assume an upper limit of temperature of 380 deg. C. (= 716 deg. F.). With steam at this temperature and at 200 lb. pressure utilised as assumed above, in a perfect engine exhausting at 0·5 lb. abs., the available heat will be 251·53 units, which is 33·82 per cent. of the total heat supplied to the engine. At an initial pressure of 500 lb. the available heat will be 276·58 units or 37·6 per cent. of the total, and at a pressure of 2,400 lb. the corresponding figures are 295·78 units, or 43·28 per cent. of the total. These figures are sufficient to show how slowly the value of steam increases with its pressure, whether superheated or not. Nevertheless every increase in efficiency, however small, is worth obtaining, if it is not counterbalanced by corresponding disadvantages, and the tendency in modern power station practice is, as we have already stated, in the direction of continually higher pressures.

One of the boldest experiments yet attempted in the use of extra high pressure steam is now being

carried out at Rugby, and appropriately enough in the Willans works. There the English Electric Company, Limited, are putting down a plant, to the order of the Benson Engineering Company, Limited, of London, in which steam will be generated at the extraordinary pressure of 3,200 lb. per square inch, which will be used to drive a turbine designed and constructed in the works in question. Before entering the turbine the steam will be throttled to 1,500 lb. per square inch by means of a reducing valve and its temperature raised to 700 deg. F. by superheating. Before considering in detail the whole cycle of operations involved, we may refer to the properties of steam at the pressure mentioned, because in them lies the reason for the experiment. As the pressure in a boiler is raised the steam of course becomes denser and denser, and equally of course the water becomes less dense owing to its expansion by heat. A continuation of the process must result in the steam and water arriving at a state of equal pressure, temperature and density, or in other words being indistinguishable from one another. This occurs when the pressure reaches 3,158 lb. per square inch, the corresponding temperature being 374 deg. C. (705 deg. F.). The separation surface between the water and steam vanishes at this point and the substance can be called either water or steam with equal accuracy.

The importance of this phenomenon lies in the fact that in any boiler working at a pressure over 3,158 lb. per square inch water can be changed into steam without any surface of separation. The steam is not evaporated from the water, but the latter, with which the vessel may be solidly filled, simply becomes steam throughout its mass when the temperature becomes high enough. The latent heat has vanished and the temperature of the high pressure feed water rises continuously until it has the expansive properties of steam. The Benson boiler has therefore no need for any steam-drum, which is a matter of great importance in view of the pressure worked at, but partakes more of the nature of an economiser in which the water is steadily heated in its progress from the inlet to the outlet. It would not be profitable to discuss the design in detail from such particulars as are available, and the plant is indeed too far from completion to render any description of its component parts otherwise than premature. The fundamental principle embodied is the production of steam at a pressure above the "critical point" and how this may be utilised when obtained is of secondary importance.

The cycle of operations proposed at Rugby and the theoretical efficiency of the process, as calculated by Professor Callendar, are as follows: Water at 100 deg. F. is heated to a temperature of 706 deg. F. and a pressure of 3,200 lb. per square inch. The volume will then be 0·052 cub. ft. per lb. and the heat required for the operation 820 B.Th.U. per lb. The steam is then throttled under conditions of constant total heat, to a pressure of 1,500 lb. abs., the temperature falling to 596 deg. F. It is next heated at 1,500 lb. pressure to a temperature of 700 deg. F., the specific volume being then 0·380 cub. ft. per lb., and the total heat rising from 890 to 1,310 B.Th.U. The next step is to expand it adiabatically in a high pressure turbine to a pressure of 250 lb. This will result in steam at a temperature of 401 deg. F., with a wetness of about 8 per cent., the heat available for driving the turbine being 166 B.Th.U. per lb. The steam is then reheated at 250 lb. to 700 deg. F., increasing the specific volume to 2·68 cub. ft. per lb., and the total heat from 1,144 to 1,375 B.Th.U. per lb. An adiabatic expansion in a second turbine down to a vacuum of 28 in. renders a further 425 B.Th.U. available for work. Work equivalent to nearly 10 B.Th.U. is required to pump the water back into the boiler at 3,200 lb., thus completing the cycle of operations.

The heat available for work in the two turbines is 571 B.Th.U. and the total heat supplied is 1,471 B.Th,U., so the overall efficiency is theoretically 38·8 per cent. The low pressure turbine alone, working with an available heat of 425 B.Th.U. out of a total of 1,305 B.Th.U., is working on a cycle with a theoretical efficiency of 32·5 per cent., and doing this, moreover, without the use of pressures or temperatures greater than are permissible in current practice. The margin in theoretical efficiency by adopting the whole of the cycle discussed, does not appear very striking, but it is nevertheless sufficient in Professor Callendar's opinion to promise a profitable advance in practice, if the boiler, superheater and turbine do not give serious trouble. More than half the heat, as he has pointed out, would be added to a practically homogeneous fluid in a boiler without steam space. The Rugby plant is designed for a total output of 1,000 kw., so that the high pressure turbine will be a very small one quite apart from the limitations imposed by the steam pressure at which it works. Supposing that it had an efficiency-ratio of only 50 per cent., it would absorb only 83 B.Th.U., passing on an equal amount to reduce the work of the intermediate superheater. With this efficiency ratio for the high-pressure turbine, the steam leaving it would be dry instead of wet, thus minimising the danger of blade erosion. As the low-pressure turbine is only working under conditions within the range of experience, its performance can be accurately forecasted, and it is indeed not proposed to construct this turbine at all at the outset.

Whatever the result of the Rugby experiment, Mr. Benson is to be congratulated on his courage in attempting so marked a change from accepted practice as regards the generation of steam. That there are possibilities in his method is undeniable, but it is equally certain that the process will present its own peculiar difficulties. Not the least of these, we imagine, will be that of throttling a hot fluid with a density of 0·052 cub. ft. per lb. from 3,200 lb. to 1,500 lb. pressure. He is well into the region of hydraulic pressures, with temperature difficulties super-added. The governing of a turbine working with a pressure of 1,500 lb. per square inch is also a matter which requires consideration. The governing problem, moreover, will become much more difficult when the low-pressure turbine is added. Intermediate steam heating involves the presence of a comparatively large amount of steam in the heater and its connections. This steam has passed the governor valve and is, so to speak, out of control, and ready to drive the low-pressure turbine without reference to anything the main governor is doing. Close governing is therefore anything but easy. This difficulty has, we believe, been experienced acutely in certain plants with intermediate re-heating and is exercising the minds of designers. It is not therefore peculiar to the Benson plant, and no doubt will be overcome in this case as in others.

INTENSIVE LOCOMOTIVE OPERATION.

A SHORT life and a merry one, or at least a strenuous one, appeals to the average citizen of North America much more than the honour and dignity which comes with advanced years. The idea permeates the action to the extent of influencing life in all directions, and it affects the national attitude towards mechanical design so that American engineering practice differs radically from that of the older hemisphere. It is the avowed custom in the United States to produce, speaking of course in quite general terms, machines constructed in such a way as to prevent them persisting beyond the end of their most useful life. An American might prefer us to give them credit for a little more than this implies, which we may do by stating the case somewhat differently. In America it is claimed that the design and quality of manufacture are so proportioned that the economic life of the machine terminates automatically when the plant has become obsolescent and is due to be replaced by newer and more advanced means or methods. This is not our attitude over here, with the result that firms have on their books old plant which they are reluctant to write off though its retention may actually handicap them in competition. The machine probably has been excellently maintained, and is capable of accurate work, but it may be completely outclassed as regards speed and output.

The danger of the American system is its tendency to encourage laxity in maintenance. A machine is operated at full capacity till worn out, and then scrapped; but clearly maintenance must be such that operation will be relatively free from breakdown, otherwise the performance over a period will be unsatisfactory. In locomotive circles the guiding principle on the large systems has for many years been intensive working. Twenty-five years or so ago the system of pooling was introduced with a view to keeping locomotives more continuously at work than for the short terms corresponding with human endurance. Railway operation often affords a variety of means of handling train mileage, but all have to take into account the human factor and the regulations which nowadays circumscribe the employment of labour. As a rule these regulations tend to reduce the return which it is possible to obtain from capital invested in machinery, whereas we all recognise that in the case of expensive plant the capital charges are such that it is advisable to keep it in as constant employment as possible. It has long been recognised that the actual number of hours an engine is employed moving trains is very low compared with the total in the year. The pooling system endeavoured to increase them, and hot water washing out, and other improved methods of handling locomotives at depots, added considerably to the mileage possible in a given time.

The direction which recent efforts have taken has had some very interesting results, and appears to be developing practice along lines which we believe to be quite new for regular operation. In an ordinary electric power station, the plant is continuously operated by shifts of men taking turn about. As one gang goes off another comes on duty to take over and carry on with the same machines, change only being made to meet the requirements of load, or to ensure regular inspection and attention being given. In marine work the same practice obtains, and the question is logically asked why locomotive practice should be the only branch of power production in which it is considered necessary to lay off the machines as well as the labour at the end of the union working day. The large systems on the North American continent seem to have convinced themselves that this is not by any means necessary, as figures recently published in our contemporary, the *Railway Review*, go to show.

The present record for continuous runs in regular operation is held by the Missouri, Kansas and Texas Railway, which works its locomotives through in passenger service for a distance of 678 miles. These engines are of the 4–6–2 type, and, as will be surmised, are oil burners, which fact of course at once eliminates some of the reasons for laying an engine off after some hours' work. The trains are regularly made up of 12 cars and the average speed is 32·7 m.p.h. The crew is changed three times on the run. Now the engines on this service average 9,867 miles per month and 115,000 miles between shoppings. Other continuous locomotive runs in passenger service on this railway are 412 and 404 miles in length. The Santa Fé line has a regular run of 602 miles, while on the Southern Pacific oil burners are being operated on continuous runs 536 and 475 miles in length and locomotives are averaging from 9,000 to 11,000 miles per month. With coal burning engines it would be expected that the practicable distances would be considerably curtailed, yet the Union Pacific Railroad is working passenger locomotives through on runs of 509 and 563 miles, the latter being at present the record for coal burning engines. In these services the average schedule speed is in some cases 41 m.p.h., and the trains are made up of 12 heavy all-steel cars. Formerly the 563 mile run was made with four different locomotives and three changes of crew *en route*. While these are the longest runs there are a large number regularly worked over distances between 300 and 400 miles, some with oil and some with coal. On the "Soo" Line runs have been extended till passenger locomotives are doing 7,800 miles per month and from 134,000 to 171,000 miles between shoppings, while on the St. Louis–San Francisco one engine has done 193,245 miles between shoppings.

In freight service, while the runs are shorter the improvement in machine performance is rather more marked since freight trains move more slowly over the road. The effect, therefore, of keeping an engine attached to a through freight train is to result in a relatively greater increase in the time

spent in useful work. In freight service continuous locomotive runs of 278 miles are made on the Baltimore & Ohio with coal burners, stoker fired, the engines averaging about 5,000 miles per month. On the Kansas City Southern freight runs of 228 miles are operated so as to give a monthly mileage of over 11,000, which is extremely high for this class of work, the engines making as much as 141,000 miles between shoppings.

We could quote many other instances from those given in our contemporary, all much to the same effect. The development has resulted in the freeing of engines for other work, obviating the necessity of purchasing more power. It has in some cases eliminated completely the intermediate depots, with the staff, thus effecting a considerable direct saving. There is some evidence to show that it has a tendency to keep the firemen up to their work, because if they hand over an engine with dirty fires and in bad condition at the end of their section, they risk having the same done to them on a subsequent day. It is stated that when these long continuous runs were inaugurated for regular service, engines were maintained at intermediate points in case of emergency. These have not been found necessary and are no longer kept ready. The saving in cutting out shunting movements and in fuel in making continuous runs, rather than shorter return runs with lay-overs, is found to be considerable, but it has to be remembered that with rocking and dumping grates and hopper ash pans American locomotives are better able to keep fires in good condition for continuous work than would be possible here. It may be mentioned that the endeavour is made to keep engines on the same run, and to assign the crews as far as possible always to the same engine.

THE ROYAL SOCIETY SOIRÉE.

SOME of the exhibits of the second Soirée of the Royal Society, held last Wednesday, had already been shown at the first Soirée with which we dealt in our issues of May 18 and 25. Two of the demonstrations then given, experiments with the frenophone of Mr. S. G. Brown, F.R.S., and the kinematograph exhibition of Mr. Walter Heape, F.R.S., were also repeated, the latter with additions. The camera of the Heape-Grylls rapid cinema machine, which was shown in photographs, exists in one specimen only, and that is used by the Admiralty at Shoeburyness; it weighs 4 tons, but can take up to 5,000 photographs per second. The selected enlarged films displayed had been taken at rates of 2,000 or 3,000 per second and were actually projected on the screen at the rate of 16 per second. The new films showed the explosion of a glass globe, 15 in. in diameter, by means of a powder charge placed inside the globe within a small glass bulb; the forty films, which represented a time period of $\frac{1}{40}$ second, showed a peculiar growth, like a regular swelling, of the globe to nearly four times the original diameter, under the pressure of the water; the glass was splintered into fragments, about $\frac{1}{16}$ in. thick, up to 7 in. in length. On another film, illustrating the passage of a bullet through 4 in. of glass, the bullet soon disappeared in the cloud of powdered glass surrounding it after perforating the plate. The piercing of a steel plate was also exemplified.

The International Western Electric Company of New York also gave instructional kinematograph demonstrations, comprising some of homely interest, since they showed Sir J. J. Thomson inspecting the high-power valve tube of the company in their research works on his recent visit to America. Another film explained the action of an audion (thermionic valve), others again the manufacture of telephone apparatus; one of these films was a "trick assembly" film: the parts of a microphone and telephone were seen to crawl or to run together, automatically assembling themselves under the influence of invisible forces. Another exhibit of the Western Company, the public address or announcement system, was effective but less pleasing. On the gallery of the library had been placed a special microphone connected to a three-stage amplifier feeding four projectors; the current for the operation, a 12-volt battery for the valve filament and 250-volt battery for the plate, were evidently of amply sufficient strength. The company further showed specimens of permalloy, an alloy distinguished by an extraordinarily-high permeability for fields of very low intensity (the alloy is nearly saturated in the earth's magnetic field, in fact) and by a greatly reduced hysteresis loss. This alloy finds extensive application in telephone and telegraphy work; it is a nickel-iron with 80 per cent. of nickel.

When we noticed the historical exhibits of the Science Museum, South Kensington, on the occasion of last month's Soirée, we did not mention the model of a "groma," an instrument used by Roman land surveyors for setting out lines on grounds for camps and towns. The original was found in Pompeii in 1915, and Colonel Lyons had the model prepared from drawings and information supplied by the Director of Excavations, Mr. Mateo della Corte. The groma is a stand, about 10 ft. high, supporting at the top a horizontal arm which can turn about its pivot in the stand and which bears at its free end a wooden cross made of two bars pivoted at its centre. A pair of plumb lines is suspended over pulleys on each bar; the two weights of the one bar were conical, those of the other pear-shaped. The stand, made of bronze like the weights, would be spiked into the ground by the side of the boundary stone, so that the pivot of the cross would be above that stone.

The early types of electric discharge tubes, shown in operation by Dr. G. W. C. Kaye on behalf of the National Physical Laboratory, also had historical interest; the photomicrographs of woods of very light weight and low thermal conductivity were mentioned last month. The crystal models, exhibited by Sir William Bragg—recently appointed Fullerian Professor of Chemistry and Superintendent of the Royal Institution in succession to the late Sir James Dewar—and by Mr. W. T. Astbury, exemplified optical activity and inactivity. Racemic acid may be represented by two types of models, one of which is the mirror image of the other; the crystals of the acid are inactive. Tartaric acid has the same structure, but the crystals are of one type only and are therefore optically active. A further model, of the molecules of basic beryllium acetate, shows a perfect tetrahedral structure.

The Demetre Daponte stereoscopic projector, exhibited by Mr. E. Sanger-Shepherd, throws a pair of stereoscopic photographs on an ordinary lantern screen without necessitating the use by the observer of interrupting shutters or special spectacles. The two photographs are taken from two slightly-separated positions and are projected by two optical systems. Between the source of light and the transparency is placed, in the path of each system, a rotating shutter consisting of a glass disc covered with a graduated grey film, which passes from black at one point (the zero) to white at 180 deg., and back to black again at 360 deg. When the one shutter transmits maximum light, the other shutter is at the minimum position; the rotating shutter dissolves the right-hand picture into the left-hand picture, and *vice versa*. With the discs at rest in the 90 deg. position, the picture appears like a print from a negative with a double exposure; on setting the discs rotating, the picture jumps into stereoscopic relief, and this can be seen with the aid of one eye; this is the novelty. The instrument is a box in which the lantern beam is, by the aid of two pairs of parallel glass plates, one silvered, the other three half-silvered, split into a right-hand and a left-hand beam. The first pair of parallel plates are inclined at 45 deg. to the right, and the first disc receives its light on its left half; the second pair of plates is inclined to the left, and sends the beam to the right half of the second disc; the two beams leave the box through collimators.

Mr. A. Mallock, F.R.S., exhibited a novel type of test-plates for microscope objectives. With the aid of very sharp diamond splinters he rules lines on dry films of methyl violet, coated on glass plates in layers of a thickness of $\frac{1}{20}$ wave-length, so thin, in fact, that the colour cannot be distinguished. The ruling consists of bands, each of 10 lines, intersecting one another at 15 deg. The spacing between the parallel lines of a band are such that there would be, in different plates, 10,000, 15,000, 20,000 or 30,000 lines to the inch, and the spacings are at the doubles of these numbers between the intersections. The visibility of these lines depends upon the opacity of the film, and not as usual with diatoms or engraved lines—which were likewise shown—on the variations of the optical thickness of a transparent material. The true resolving power of an objective, Mr. Mallock pointed out, is a function of the lens and not of the object examined, and observations made on corrugated surfaces give an exaggerated impression of resolving power. Mr. Conrad Beck's illuminator for opaque microscope objects was mentioned last month.

In our days of rapid developments the exhibits of Dr. E. E. Fournier d'Albe, photographs broadcast by radiotelephony from London on May 24 and June 18 last, will soon have a merely historical interest. He divided the pictures up into squares and indicated the average luminosity of each square by letters of the alphabet, using seven symbols for his grades of luminosity; these letters he dictated in sets of five into a microphone. The recipient reproduced the pictures from this code either with a special typewriter or by means of graduated dots on squared paper.

Mr. Harrison Glew's curious levitating magnets—repelled by strong similar poles underneath them—were noticed last month. This time he had suspended weights from his magnet rods of cobalt steel to measure the repulsive effect of similar poles on one another, and had also attached two wires to the end of the levitated rod, the wires dipping into mercury cups; when the repelling electromagnet was excited, the rising rod threw in resistance through the mediation of the mercury cups, sank again, and was thus kept oscillating up and down 200 times per minute. He further suspended the bars (without external field) by cords, all N-poles upward; the magnets then arranged themselves on a conical surface, the apex being the point of suspension. When there were, *e.g.*, six rods, and he pulled one of them out like a pendulum, it disturbed the whole group in swinging back, and there would be a struggle before the system came to rest again. With six rods, one rod would go to the centre, the others grouping round it; with eight bars two would go to the centre, but the central rods might be pushed out and replaced by others before quiet was restored. These suspended rods show the symmetrical groupings of magnets—frequently used to illustrate the grouping of atoms under mutual forces—better than Meyer's original floating magnets.

The beautiful specimens of substituted nitrohydrazones of Dr. F. D. Chattaway, F.R.S., of Oxford, well illustrated the polymorphism and marked colour changes produced in these compounds by potash and by strong mineral acids.

We finally should like to allude to two of the many exhibits of biological and physiological character. We stated last month that Dr. Leonard Hill, F.R.S., and Dr. A. Eidinow had observed that the ultraviolet light of quartz mercury lamps had a more rapid lethal effect on organisms than red light, as one might expect. This time they exposed the organisms simultaneously to ultraviolet light from the right, and to red light from the left, so that the total light was more intense than with ultraviolet illumination alone; yet the effect was decreased. This agrees with the observation made by Dr. Hess, in America, that the cure of rickets by mercury light is actually impaired if red light is also admitted—an obscure case of physiological interference, apparently. The other exhibit concerns the so-called age-ring markings on the scales of herrings. It had been asserted that these scales show annual rings like trees; but Mr. H. J. Buchanan-Wollaston, of the Lowestoft Fisheries Laboratory, finds that the outer rings on the larger scales at any rate are so grouped that several rings may belong to the same year.

NOTES.

THE BRITISH STANDARD PORTLAND CEMENT SPECIFICATION.

THE British standard specification for Portland cement was first adopted in 1904, since when it has been several times revised. In the process it has been made rather more stringent, and certain features which further experience have proved to be valueless have been jettisoned. That the

specification might with advantage be stiffened still more formed the argument of a paper on the subject of this specification, read last night before the Institution of Structural Engineers, by Mr. D. B. Butler. One of the points made by Mr. Butler relates to grinding. This is one of the directions in which revision has already had effect, but the author's case is that the fineness limits required are not sufficiently good, and that they are normally well surpassed by all good British cements, while the 14 per cent. residue allowed on the 180 sieve is about twice that obtained on the average with foreign cements. The fact that the British figure is so far surpassed rather suggests that we are too lenient in our specification. Another point to which the author directed attention was the low figure for tensile tests. The British specification requires for the seven days' test, 400 lb. per square inch for neat cement and 150 lb. per sq. in. for sand-cement mortar. The best cement develops about double the specification figure, while, an average of British and foreign makes gives a figure more than 50 per cent. above the specification requirements. Mr. Butler, therefore, suggests 600 lb. and 300 lb. for the seven-day test, stating that foreign cements give such high figures that the only conclusion possible is that we have been satisfied with too low a standard. With regard to foreign specifications the point is made that methods of preparing cement for testing differ so much that a cement passing the British standard to-day would not necessarily pass the tests of the United States or the Argentine, for instance, but the raising of the test requirements here would help to keep the British product up to a standard which would enable it to pass foreign tests in which more water is used for mixing.

MADRAS IRRIGATION.

The productive irrigation works of Madras were responsible for a rather smaller net revenue in 1922 than in 1921, although the return still remained satisfactory. The actual revenue was Rs.82,59,219 on a capital expenditure of Rs.6,25,57,188, producing a return of 13·2 per cent., compared with 13·86 per cent. in the previous year. The working results of the several systems which come within the classification vary greatly. The Western Delta of the Godaveri system, which irrigated 755,358 acres for first crop and 221,761 acres for second crop, heads the list with a profit, after paying interest charges, of 16·01 per cent. This is rather below recent years, 1921 having shown a profit of 16·64 per cent., while the year before actually showed 21·84 per cent. The next most successful work is the Kistna Delta system, irrigating nearly as much acreage for first crop and giving a profit, after paying interest charges, of 14·28 per cent. This, again, was rather below the figures for previous years. Of the other large works, the Lower Coleroon Anicut system, irrigating 109,127 acres, returned a profit of 8·93 per cent., while the Cauvery system, the largest of all and irrigating in 1922 some 893,572 acres for first crop, showed a clear profit of 6·92 per cent. This compares rather unfavourably with the 14·27 per cent. return of the previous year, but working expenditure during the year was exceptionally heavy, due to breaches, while the area under second crop was much reduced as a result of unfavourable climatic conditions. In the Penner River Canals system the area irrigated showed some increase on former years, and the gross revenue was improved, but with maintenance expenses also higher the net profit remained much the same, at 5·31 per cent. The famous Periyar system, by means of which some 130,000 acres are capable of being placed under irrigation for first crop, gives a rather lower return, viz., 2·4 per cent. profit after payment of interest charges. The working expenditure, which is always heavy, was increased by work which was urgently necessary in the way of clearing loose stones and boulders from the Periyar Tunnel, involving a good deal of blasting. Of the smaller productive works the most successful during the year were the Poiney Anicut system, returning 11·31 per cent. after payment of interest charges, and the Tirukkoyilur Anicut, with 12·37 per cent. The Divi pumping system showed a clear profit of 1·45 per cent. This system does not show a large return, and the interest account is in arrears by Rs. 2,24,154, which, however, is being slowly worked off. A new pumping set is being added to this plant. There are 40 undertakings which are classified as unproductive; the net revenue on these taken together amounted to 1·77 per cent. on the outlay, the average being brought down by the Kurnool-Cuddapah Canal, which, on a large capital, shows a return of 0·43 per cent. This system is an unfortunate heritage. It formed an isolated section of a great scheme embarked upon in 1862, without adequate investigation, by a private company backed by Government. Such work as was done was badly executed and money was wasted. Government finally bought out the company, but the project remains a heavy drag on the finances of the Presidency.

THE FRENCH NAVY.

The French naval budget drawn up by the Chamber of Deputies, will amount to a total of 1,000,000,000 francs, following upon the reduction it has undergone on passing through the Senate. This total sum, says *Le Moniteur de la Flotte*, is less than 400,000,000 francs at pre-war rate. Our contemporary adds that in 1914 the navy absorbed 16·52 per cent. of the total budget (not including the Debt Services), whilst in 1922 it enters in the total for 7·69 per cent. only. In this connection, Mr. H. Berenger, the official entrusted with the naval budget, has stated that the naval programme voted by the French Parliament cannot be considered as being final. In order to have an adequate fleet, in keeping with the country's needs and capable of undertaking the defence of the Colonies, the Navy Department will have to be provided with much more ample means than are now made available. The naval budget is exceedingly small compared with that of other departments the provision for whose requirements is on too high a scale, but it will be largely increased in 1924, when the naval policy of the country is finally agreed upon. As it is, the new credits will not be ill-spent. The budget for 1923, although hardly higher than the preceding one, embodies a greater proportion of expenditure on the effective services, whilst the expenditure on the non-effective services is gradually decreasing. Mr. Berenger feels confident that by close collaboration between the Ministry of Marine and Parliament, the naval budget for the year 1924 will start the real revival of the French Navy coupled with its complete reorganisation. Among other statements, Mr. Berenger says that in order to defend the French sea coasts it is not sufficient to distribute over their length all classes of fixed and mobile protective means. The best defence for a coast is the offensive action by a fleet attacking the enemy off-shore, by bringing into action surface ships, submarines and aircraft; for this work real sailors capable of navigating the three classes of units are required. He advocates the formation of a board for centralising scientific researches. Comparatively small supplementary credits cover the supply of mines, experiments with a battery of 34 cm. (13·386 in.) guns, the purchase of aircraft and the establishment of aircraft naval bases.

THE STRENGTH OF BRICK PIERS.

Whilst tests on the strength of stone, bricks and other component parts have been numerous, there have been relatively few experiments on the strength of the masonry constructed from these units. A notable exception was afforded by the tests on the strength of brickwork piers organised by the Royal Institution of British Architects in 1895. A notable addition to the data then secured has been made by Professor A. H. Beyer and Mr. W. J. Krefeld, at the Civil Engineering Testing Laboratories of the Columbia University, New York. In this research, 135 masonry piers were tested. All had the same section, viz., 12 in. square, but 115 were 40 in. high and the remainder 84 in. high. The materials used were clay bricks, sand-lime bricks, bricks made out of concrete, and there were also four monolithic piers of concrete. A 1 to 3 Portland cement mortar was used throughout. An interesting difference was found between the method of failure of the piers built with clay bricks and those built with concrete bricks. The latter failed generally by diagonal shear much as if they had been monolithic, which seems to indicate that the effectiveness of the bond between the concrete bricks and the cement mortar is comparable with that between the cement and the aggregate in the concrete. With piers of clay bricks, on the other hand, the first sign of failure was the appearance of a fine vertical crack either in the mortar or in a brick in line with a mortar joint. A number of such cracks developed simultaneously or in close succession on all four faces of the pier, and in most cases the damage was confined to the middle two-thirds of the height of the pier, which failed by progressive disintegration of the component parts. The behaviour of the sand-lime bricks was very similar. The tests on the 84-in. piers showed that the loss of strength due to increased height was greater the lower the strength of the masonry. Thus in the case of the clay bricks the average strength of the pier 40 in. high was 0·424 that of the single bricks. With the piers 84 in. high this ratio fell to 0·38. With the concrete bricks there was no material difference in the strength of 40-in. and of a 84-in. pier. Measurements were also made of the elastic modulus of the piers. After 90 days the clay brick piers showed an average elastic modulus of 1,400,000 lb. per square inch, which for the piers built with concrete bricks rose to 1,660,000 lb. per square inch, whilst the modulus for the monolithic piers attained 3,405,000 lb. per square inch.

LITERATURE.

Etudes Elémentaires de Météorologie pratique. ALBERT BALDIT, ancien officier de Marine. Deuxième édition. Paris: Gautier-Villars et Cie. [Price 24 francs.]

THE author of this work took active part in the meteorological work inaugurated during the war on the French front, appreciated the assistance its organisation rendered to military manœuvres on the one hand, and noted the influence exerted on the public on the other, as evidenced by increased interest in all that refers to weather forecasting, to meteorology, and to the study of atmospheric phenomena generally. Ardent in observation, trained in physical science, and eager to promote the interests of industry, he seeks to make the energy so lavishly displayed in war serve the needs of peace, by assisting aerial navigation, encouraging agriculture or, it may be, by aiding the tourist. By examining the machinery devised at the front for the spread of precise information, and noting the fruitful results that increased as experience increased, he is led to sketch a plan that would add to the accuracy of weather forecasting, advance the progress of meteorology as a science, and breathe fresh life into its methods now grown somewhat stagnant under the uninspiring monotony of climatology. Briefly, he proposes to divide the area of France into a number of divisions, probably nine, each having well-defined climatic factors. A central establishment would be provided for each of these divisions with an adequate staff and instruments, for collecting information locally, and would also receive and discuss the reports from subsidiary stations, communicating the results to a central Geo-physical observatory, one of whose departments would be devoted solely to furthering the interests of meteorology.

The scheme indicates what the author would have us to understand by "Météorologie Pratique"—an energetic inquiry, conceived in the interests of the public, that would busy itself in deriving results that would find useful application in every direction. The full scheme would naturally entail considerable expense, and M. Baldit exhibits a very hopeful spirit in believing that the return would be rapid, and in a short time prove remunerative. The scientific spirit must not only animate the participants in the scheme, but must be shared by the public if the recommendations are to be accepted with confidence and methodically employed. Time is necessary to overcome prejudice and to give a sense of added security. An extra expenditure supplies a very insufficient argument against introducing sound scientific measures, but the entire plan works out rather costly. Each of the nine first-class stations, working day and night, would require the services of some 20 observers. These would include, besides the scientific staff engaged in deducing and transmitting forecasts, the crews necessary for

aeroplane flights, for working a captive balloon, for "kites," and other appliances for exploring the upper air. In addition must be considered the collectors of information from outside and less fully equipped observatories, who might not be wholly occupied, but involving a considerable addition to the cost. Of course, it is proposed to utilise the existing services at present scattered through the departments of War, Marine, Agriculture, the Air Force, &c., and by re-grouping these qualified meteorologists, it is believed to be possible to have a sufficiently trained staff capable of dealing with all ordinary problems, and prepared to attack the new questions that would of necessity arise and act as stimulants to further inquiry.

M. Baldit having formed his ideal observatory asks how ought the work to be organised. He recognises that distinct orders of co-operators, variously equipped, will be required in the threefold task of collecting, discussing and utilising the facts on which scientific forecasting must ultimately depend. The observation of the weather and its frequent changes will claim a prominent place, and captive balloons, kites, aeroplanes will be pressed into the service of exploring the atmosphere and with greater efficiency than in the past. Next the discussion of this information so as to present the operating factors in the most advantageous form for facilitating the work of forecasting for longer or shorter periods will require a special staff, to whom will be entrusted the duty of providing a rapid and convenient solution of the ordinary problems connected with air motion and gradients. Finally, the chief of the station will devote himself wholeheartedly to the task of improving the methods and scope of forecasting. That is the order in which the principal problems present themselves to the mind of the meteorologist, who will enter upon new and wider functions in the future.

It is in this order, and with the view of assisting the ever-increasing class who interest themselves in meteorology as a science and would add to its utility, that the author has arranged his material, warning the reader that little is contained in these pages that will be found in the ordinary treatises on the subject. The book is accordingly divided into three parts. In the first section after a few pertinent remarks on the choice of a station, a very brief description is given of the fundamental instruments in use and of the methods of mounting. On the other hand, very full and clear details of the equipment and maintenance of the lesser-known forms are supplied, as, for instance, the "*ballon captif*" and the "*avion météorologique*," the author enriching these chapters from his war experience. Particular attention may be directed to the method of determining the direction and velocity of the upper air currents by the observation of the explosion of shells from artillery. The last three chapters in this section are devoted to the work of collection of observations of clouds, storms, squalls and other phenomena, all utilised in the construction of weather charts. This full treatment should prove useful and encouraging. Too many amateur observers are content to record, being unable or unwilling to make their observations available for the construction of the practical synoptic chart, or to learn to draw conclusions from the deductions of others.

The second part treats many of the ordinary problems connected with the barometric pressure and the wind on physical lines, but rigorous discussion is hardly possible in the present stage of practical meteorology. As the author points out, many of the problems that come before the meteorologist demand a quick, if approximate, solution, for the necessities of aviation or of military tactics require decision. Moreover, other data that would affect the conclusion have often to be omitted, because they are ill-determined or perfectly unknown. But the discussions here given may well serve for a model particularly where the dynamical relations between pressure and wind are concerned. The remarks on wind friction and on irregular turbulence are very instructive, and will be much studied in the future as they materially affect aerial navigation.

One half of the book is devoted to the third division, the problem of forecasting which the author considers the end and aim of investigation. The problem is easily stated: Knowing the pressure, temperature, velocity and direction of the wind, &c., with more or less inexactitude over a certain area, at the times t_n, t_1, t_2, . . . t_0, can we tell the value of these same elements at the epoch $t_n + 1$ at any point within the area concerned? Is the problem hopeless, as many think? Can it be approximately solved by the methods in use to-day? Remembering how little we know of the conditions that obtain in the atmosphere at considerable heights above the surface, or of the laws that govern and the reactions that prevail in those unexamined regions, it is difficult to oppose the assertions of pessimists, who declare that a solution will never be forthcoming. We may not yet be on the right road that leads to the unravelling of the complete problem, but it is not impossible to apply the laws of thermodynamics to characteristic and relatively independent phenomena, such as the formation of cyclones and anti-cyclones, which we see clearly indicated on the daily weather charts. This we understand to be the modest *rôle* that M. Baldit recommends and would pursue. To further this end, he describes lucidly and earnestly the present position of the more important problems that meteorologists have attacked, the degree of success that has been attained, and the paths whose pursuit offers the most promising results in extending the practical applications of the science.

The Shirley Institute Memoirs. Vol. I, 1922. Published by The British Cotton Industry Research Association, Didsbury, Manchester,

THE cotton industry was certainly among the earliest, if not the first, to perceive that a carefully planned, systematic and continued application of the principle and practice of science was necessary for its progressive development. Convinced that increased knowledge and the adoption of scientific methods could alone ensure the maintenance of the pre-eminence that has long distinguished the staple industry of Lancashire, the leading manufacturers readily embraced the offer of the Department of Scientific Industry and Research to take the necessary steps for carrying out the plan that Government recommended and was willing to subsidise. Able and enthusiastic committees, constituted in December, 1916, generously supported by the bulk of the producing firms, have organised the British Cotton Industry Research Association, placed it on a permanent footing and amid surroundings worthy of the wealthy corporations interested. They have given it a local habitation and a name, supplied a competent staff, organised its proceedings, and we have now before us the first fruits of its activities.

How this result has been achieved is told in one of the collected papers by Mr. Kenneth Lee, the chairman of the association, who sketches the policy that has guided the committee, and shows the details of the scheme that has fructified in their hands. Laboratories, thoughtfully planned for present use and capable of extension in the future, accommodate the physicist and the botanist, the chemist, whether he specialises in organic, colloidal, or biochemistry; the optician, the photographer, the electrician, are all provided for, while a range of workshops is utilised for drawing offices, machine and carpentry work, all tending to make the Shirley Institute at Didsbury a complete and self-contained unit. The estate surrounding the main building is sufficiently ample in extent to prevent any inconvenience from the traffic and vibration inseparable from the suburb of a large manufacturing city, and at the same time, to permit the erection of a number of houses to accommodate the resident staff.

The policy pursued by the promoters is as important as the arrangement of detail. Co-operation has to be invited between firms in active competition with each other, the jealousies between allied, but distinct, organisations have to be allayed, and last but not least, the distrust that labour fosters against capital and the fear that mechanical devices may operate adversely to individual interests, must be overcome. The leaders of the movement had the foresight to recognise, that if the Research Association was to fulfil its mission all sections of the industry must be combined and work together loyally to accomplish a common purpose. Failure was inevitable, if any one branch sought for a solution of some definite problem affecting a particular interest: the solution of the many-sided and mutually reacting problems must be sought by the whole body of workers, animated by a single purpose and co-operating under the guidance of one director. It is therefore a matter of congratulation and a promise of future success, that the Council of the Association includes representatives of the Federation of Master Cotton Spinners, Cotton Spinners and Manufacturers Association, the Federation of Calico Printers, and the Federation of Dyers and Finishers. Perhaps, even a greater victory has been won by enlisting the assistance and co-operation of the operative class. The history of the Lancashire cotton industry shows that there have been crises, when the working classes have combined to prohibit the use of mechanical appliances, and to defeat the efforts of those whose ingenuity, by promoting cheaper and better production, enlarged the sphere of operations and promoted the welfare of all engaged in the industry. Those days of prejudice and short-sighted selfishness may not have entirely disappeared, but surely it is of happy augury that no small number of the leaders of labour organisations exhibits an intelligent appreciation of the objects of the new movement, and are to be found at the same Council Board actively co-operating with capitalists and employers.

Besides the paper descriptive of the establishment and its aims, which has been treated at some length, nine others are included in the volume. These give evidence of thoroughness and solidity, but in these early days—the laboratories were formally opened by H.R.H. the Duke of York, on March 28, 1922—the work must be expected to be preparatory rather than original. The inquiries are directed for the most part to the examination of existing information, and the determination of the properties of the material which forms the basis of the industry. The first paper by Drs. George Fargher and John C. Withers attacks the subject on the historical side and they contribute a thorough digest of the investigations that have been made in recent times into the chemical constituents of raw cotton. Greater correctness of interpretation of observed facts and of the growth of accuracy are well illustrated on many points, but the large and in some respects the vexed subject of the properties of cellulose is dropped rather sharply, reference being made to the published summary of Hibbert (1921). The physical properties of cellulose are discussed by Mr. G. E. Collins, M.Sc., who shows clearly what has been accomplished in the past, but also emphasising the necessity for continuing investigations, since the collected information in certain directions is vague and scanty. Among the properties that have been neglected and call for further examination are compressibility, rigidity, thermal expansion, diathermancy, absorption and reflection of light, absorption of X-rays, magnetic rotation of sols, and magnetic susceptibility, a fairly imposing list of lacunæ. Another historical paper or summary of existing literature is that by Mr. P. H. Clifford, B.Sc., on oxycellulose, whose presence has been regarded as the cause of yellowing of cotton on steaming, but whose precise nature remains indetermined. Oxidation of cellulose is probably accompanied by hydrolysis, and the essential products of either reaction are probably not conclusively distinguished. The authors make no attempt to determine whether the conditions admit of concurrent hydrolysis or not. They are content to record rather than to criticise, since the work at present in progress in the laboratory will give valuable additional information.

A paper on the structure of cotton hair is submitted by Mr. H. J. Denham, M.A., who again summarises the results of previous researches, which in many respects are declared to be faulty and incomplete. It must be admitted that though the physiology and genetics of the cotton plant have been the subject of much study, there are still many gaps to be filled in, necessary to explain the structure and properties of the cotton itself. The most singular feature of the cotton hair is the ratio of its breadth to its length, which in good Sea Island cotton may be as much as 1 : 4,000: and the most inexplicable is the mode of formation of the openings and "pits" in the hair wall, which have practical importance as they influence the dyeing of the fabric. Precisely similar "pits" are not found elsewhere in epidermal cells, but apart from

these peculiarities "there is little in the cotton hair that does not find a parallel in plant anatomy." The same author, in a second paper, "On the Destruction of Cotton Hair by Micro-Organisms," points out, that these "pits" may be a possible source of deterioration of cotton yarns and fabrics, whose cause is at persent but imperfectly understood, though the weakening effects are easily perceptible in an advanced stage. Mr. Denham shows that at several points the cotton hair is particularly vulnerable to the attack of micro-organisms, and among these are abrasions, shallow cracks, and "pits." The fairly obvious conclusion is drawn, that it is desirable to guard against the possible development of micro-organisms in all stages of manufacture, and that processes which involve the addition of water to cotton, as the "conditioning," offer the means for easy attack. The Institute is admirably equipped to investigate this problem of damage by organisms, and the subject will be exhaustively pursued.

The remaining papers are more nearly connected with the processes of manufacture and involve original research. Mr. Adderley, B.Sc., inquires into the clinging powers of single cotton hairs, and proves that this clinging power depends upon the convolutions and is a factor of importance in the spinning value of the cotton and the strength of the yarn spun from it. He also determines the conditions that make the clinging power a maximum, and shows that the maximum value can never be realised in spinning. Dr. A. E. Oxley submits two papers, one, on the "Regularity of Single Yarns and its Relation to Tensile Strength and Twist," and a second, in collaboration with Mr. F. T. Peirce, B.Sc., on "Some Physical Quantities of Mule Yarns." In the former the plan adopted for determining the regularity of the hardness of the yarn was to photograph, under high magnifying power, the upper surface of the yarn when drawn between a pair of case-hardened shoes, and subjected to a normal pressure of 2½ ounces. The diameter depends on hardness of twist, fibre concentration and fibre regularity. All mule yarns exhibit a periodicity of twist hardness, due to the intermittent action of the mule mechanism. The length of the mule draw is clearly indicated. Ring yarns show only non-periodic unevenness. In the second paper, the relation between the twist and the amount of fibre is further discussed, and a formula is found in which the twist and fibre numbers are in statistical agreement. The constants of the formula vary in a definite manner from count to count, and there appears to be a close correspondence with the mill rule, that "twist varies as the square root of the counts." The discussion suggests that it is possible to isolate the periodic variation of twist caused by the intermittent action of the mule mechanism.

In the final paper, Dr. Oxley, in conjunction with Mr. I. P. Andrews, B.Sc., exhibits the results derived from a detailed comparison of yarn spun on the Casablancas system with that spun on the ordinary low-draught ring system. As a practical result, the differences are found to be slight, but it may be claimed for the Casablancas system that the fibres are distributed a little better, are laid straighter, and probably more parallel than in the ring system. The mean length of the fibre is also a little greater than in the Casablancas yarn, but the difference is only just perceptible. The diameter, measured under compression, is less even in the ring yarn, but in respect of strength, count and twist per inch, the two yarns have identical properties.

Although it has not been possible to do justice to the industry and ingenuity that characterise the work of the staff, these notes may serve to show that the Institute is earnest and resolute in prosecuting inquiry. We offer our sincere congratulations to those who have carried the scheme to fruition, and to the director who has prepared such a plan of work and brought it to a successful issue.

BOOKS RECEIVED.

A Handbook of Testing. Vol. II. *The Theory of Prime Movers.* By C. A. MIDDLETON SMITH, M.Sc., M.I.Mech.E., and A. G. WARREN, B.Sc. London: Constable and Co. [Price 22*s.* 6*d.* net.]

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A Practical Treatise on Suspension Bridges. Their Design, Construction and Erection. With Appendix Design Charts for Suspension Bridges. By D. B. STEINMAN, A.M., C.E., Ph.D. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 20*s.* net.]

The University of Minnesota. Engineering Experiment Station. Bulletin No. 2. *The Manufacture of Portland Cement from Marl.* By RAYMOND E. KIRK. Minneapolis: University of Minnesota.

The Year Book of Wireless Telegraphy and Telephony, 1923. London: The Wireless Press, Limited. [Price 15*s.* net.]

Die Stellung der Relativitätstheorie in der Geistigen Entwicklung der Menschelt, By JOSEPH PELZOLDT. Leipzig: Johann Ambrosius Barth.

Die Rontgenstrahlen. By P. CERMAK. Leipzig: Johann Ambrosius Barth.

The Mind in Action. A Study of Human Interests. By GEORGE H. GREEN. London: University of London Press Limited. [Price 3*s.* 6*d.* net.]

Canada. Department of Mines. Mines Branch, No. 579. *Titanium.* By A. H. A. ROBINSON. Ottawa: F. A. Acland.

A Dictionary of Applied Physics. Vol. IV. *Light—Sound — Radiology.* Edited by SIR RICHARD GLAZEBROOK, K.C.B., D.Sc., F.R.S. London: Macmillan and Co., Limited. [Price 63*s.* net.]

Alternating Current Electrical Engineering. By W. TOLME MACCALL, M.Sc., M.I.E.E. London: University Tutorial Press, Limited. [Price 15*s.* net.]

Transactions of the Liverpool Engineering Society. Vol. XLIII. Edited by ASSOC. PROF. T. R. WILTON, M.A., M.Inst.C.E. Liverpool: Offices of the Institution.

Particulars of British War Vessels, Showing Principal Dimensions, Armament, Speed, &c. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 10*s.* 2*d.*, post free.]

Telephony. An Elementary Exposition of the Telephone System of the British Post Office. By T. E. HERBERT, M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price, 18*s.* net.]

Traction Motor Control (Direct Current). An Introductory Treatise. By A. T. DOVER, M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price, 2*s.* 6*d.* net.]

The Incorporated Swansea Exchange. Thirty-Fifth Annual Report, 1921–22. Swansea: Offices of the Exchange. [Price 3*s.* 6*d.*]

Vorlesungen Über Ingenieur-Wissenschaften. Vol. III. Part II. *Eisenbrückenbau.* By GEORG C. MEHRTENS. Leipzig: Wilhelm Engelmann. [Price 28 Swiss francs.]

By-Product Coking. By the late G. STANLEY COOPER, B.Sc. Second edition, enlarged and completely revised by ERNEST M. MEYERS, F.C.S. London: Benn Brothers, Limited. [Price 12*s.* 6*d.* net.]

Electric Motors. Their Theory and Construction. Vol. II. *Polyphase Current.* By HENRY M. HOBART, B.Sc., M.Inst.C.E., M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 15*s.* net.]

Proceedings of the Institution of Railway Signal Engineers. Session 1922. Reading: Offices of the Institution. [Price 10*s.* 6*d.*]

Chamber of Shipping of the United Kingdom, 1922–23. *Annual Report and Report of Proceedings of the Forty-Sixth Annual Meeting. Annual Report of the Shipowners' Parliamentary Committee.* London: Witherby and Co.

Sur la Théorie des Surfaces portantes. By MAURICE ROY. Paris: Gauthier Villars et Cie. [Price 12 francs.]

Hilfsbuch für Metalltechniker. By GEORG BUCHNER. Third edition, revised and enlarged. Berlin: Julius Springer. [Price 10*s.*]

The Properties of Engineering Materials. By W. C. POPPLEWELL, B.Sc., and H. CARRINGTON, B.Sc., M.Sc. London: Methuen and Co., Limited. [Price 25*s.* net.]

Calculus for Schools. By R. C. FAWDRY, M.A., B.Sc., and C. V. DURELL, M.A. London: Edward Arnold and Co. [Price 6*s.* 6*d.* net.]

Aeronautical Research Committee. Reports and Memoranda. No. 796. *The Possible Causes of Fire in an Aeroplane Crash and the Means that can be Taken to Lessen the Fire Risk. Report of the Fire Prevention Sub-Committee.* [Price 1*s* 6½*d.* post free.] No. 805. *Some Calculations Dealing with the Disturbed Motion of an Aeroplane, with Special Reference to Landing.* By L. W. BRYANT, B.Sc. [Price 7*d.* post free.] No. 812. *Experiments on Rigid Airship R.*32. Part II. *Controllability and Turning Trials.* By J. R. PANNELL and others. [Price 1*s.* 1*d.* post free.] No. 815. *Measurements of Normal Force and Pitching Moment on Rigid Airship R.*33. By R. A. FRAZER, B.A., B.Sc., and H. BATEMAN, B.Sc. [Price 1*s.* 4*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

ARAPUNI ELECTRIC POWER SCHEME.—H.M. Trade Commissioner at Wellington, N.Z., has forwarded to the Department of Overseas Trade plans, specifications and conditions of contract for Section 1—Headworks—Arapuni Electric Power Scheme. The work comprises headworks for a hydro-electric power station situated at Arapuni on the Waikato River. Tenders for the above will be opened by the Secretary of Public Works Tenders Board, Wellington, at noon on February 28, 1924. The plans and specifications can be seen by British firms at the Department of Overseas Trade (Room 50), until September 29, after which date they will be sent on loan in order of application to firms unable to arrange for inspection in London.

THE LATE MR. ROBERT MATTHEWS.

A PIONEER worker in many of the fields of engineering and a man of sterling worth was taken from us when Robert Matthews, for long head of the engineering branch of Sir W. G. Armstrong, Whitworth and Co., Limited, died on Wednesday, June 13. He was the happy possessor of quiet tastes and simple habits, with a deep dislike of display. There was nothing artificial about his character and he had that modesty which is the accompaniment of great abilities and extended experience. His loss leaves a gap in the ranks of British engineers, all the harder to fill because he combined in his own personality so much of what is best in man, noble purpose, wealth of experience, unstinted devotion to work and thoroughness, and he never sought after any form of laudation.

Mr. Matthews was born in Wigton, Cumberland, in 1854, and was the son of Humphrey Matthews, a millwright, who specialised in agricultural machinery. He was educated at Wigton College and received his scientific training at the Elswick Institute. He obtained his engineering training in the works of Messrs. T. Clark and Co., Messrs. R. and W. Hawthorn and Messrs. Wigham Richardson and Co. After gaining valuable experience and a reputation for his mathematical skill, he sought a new field of service in the design of hydraulic and chemical machinery and bridges for Messrs. Bells, Lightfoot and Co. His next appointment was as managing draughtsman to Messrs. J. and E. Hall, of Dartford, where he was occupied with the construction of gunpowder machinery and hoists and in the introduction and perfecting of refrigerating plant. When he reached the age of 26 he went north to manage the works of Mr. Goodfellow, at Hyde, and later became a partner in the firm. At that period he became a keen advocate of high-speed engines and did much pioneer work in their design. Mr. Matthews effected many improvements in air compressors and his firm built up a reputation on their design and construction, both at home and abroad.

He joined the firm of Sir Joseph Whitworth and Co., and was a director for the eight years prior to the amalgamation with Sir W. G. Armstrong and Co. In the new organisation he retained the office of head of the engineering branch at Manchester.

Mr. Matthews served as president of the Engineering Employers' Federation and rendered valuable assistance in the work of the Engineering Standards Committees. He was elected a member of the Institution of Mechanical Engineers in 1886 and of the Institution of Civil Engineers in 1905. Many of his friends in Manchester prevailed with him to become the president of the Manchester Association of Engineers in 1905, and he accepted that honour, but solely with the aim of furthering the interests of the society. That his work was successful is evident from the fact that on the conclusion of his term of office the members presented him with an illuminated address enclosed in a handsome silver-gilt casket of a design representing the industry and commerce of Manchester.

ROYAL NATIONAL LIFEBOAT INSTITUTION.—At the meeting of the British Motor Boat Club on the Chelsea Reach of the Thames, on the 30th inst., Lieutenant-Commander the Marquess of Milford Haven, K.C.V.O., R.N., will review the boats. It is expected that the meeting will be still more interesting than last year, as permission has been obtained to run some speed events, and one of the features of the meeting will be a motor life-boat, the first of the latest type built by the Royal National Lifeboat Institution which, with the help of Sea Scouts, will give a lifeboat display.

SURVEY OF THE NATIONAL COAL RESOURCES.—One of the main functions of the Fuel Research Board is a survey and classification of the coal seams in the various mining districts by means of laboratory chemical and physical tests, supplemented, where desirable, by large-scale tests at H.M. Fuel Research Station, East Greenwich, or elsewhere. The Board consider that the best way to carry out this work is by means of local committees, the *personnel* of which includes colliery owners managers, representatives of the Fuel Research Board and of the Geological Survey of Great Britain, as well as of outside scientific interests. Each committee is to be charged with the duty of superintending the survey work in a coal-mining area; the survey thus becomes of practical value from the commencement, since local knowledge and experience is made available, and the selection of seams decided by those most likely to estimate correctly the relative importance of the problems to be solved. The seams selected are to undergo physical and chemical examination by the local experts, after which a final selection is to be made of those likely to justify experiments on a practical scale to test their suitability for particular uses or methods of treatment. The first of these committees has now been actively at work in the Lancashire and Cheshire area for nearly eighteen months, and the Board have recently appointed a committee to deal with the survey in the South Yorkshire area. The South Yorkshire Coal Trade Association and the Midland Institute of Mining, Civil and Mechanical Engineers are co-operating in the work.

UNITED STATES NAVY CRANE SHIP No. 1.*

WHEN in an engineering structure the size exceeds certain well-tested limits, the difficulties of design and construction multiply at a very rapid rate. There have been many instances of this character. Steel bridges have been built for many years, but when it came to an enormous structure like the Quebec Bridge it was found that our knowledge of stresses of the magnitude involved was insufficient. The same type of difficulty was encountered and overcome in converting the battleship Kearsarge into a seagoing crane ship capable of handling and transporting two modern three-gun turrets complete with their guns.

"United States Navy Crane Ship No. 1," as it is known officially, but called the "Kearsarge Crane," is the only large sea-going crane ever constructed and the largest floating crane in existence. Big floating cranes have been built in the past, but only for harbour work and not for navigation in rough water or in heavy seas. The Kearsarge bears a 250-ton revolving crane of the luffing-jib type so designed that the jib may be lowered into a cradle and secured firmly for sea service. Built to handle loads of 250 tons under normal conditions, she has actually lifted 312 tons. Such loads on a floating structure impose stresses of an unprecedented character, both on the crane and the foundation, which means that all parts have to be designed with unusual care, generous factors of safety, and with particular regard to the selection of materials in order that there shall be no weakening of any part due to overstressing. To meet these conditions interesting expedients and methods of design were resorted to, both by the Navy Department, in whose hands was the reconditioning of the hull, and by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, the builders of the crane itself. Among these may be mentioned a new method of combined welding and riveting ship plates, the novel track arrangement for the crane, the rotating mechanism—provided with wheels of a new type, the methods of cradling the crane at sea, &c.

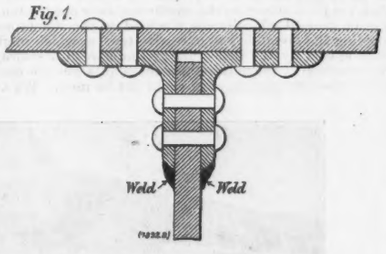


FIG. 1. DETAIL OF JOINT.

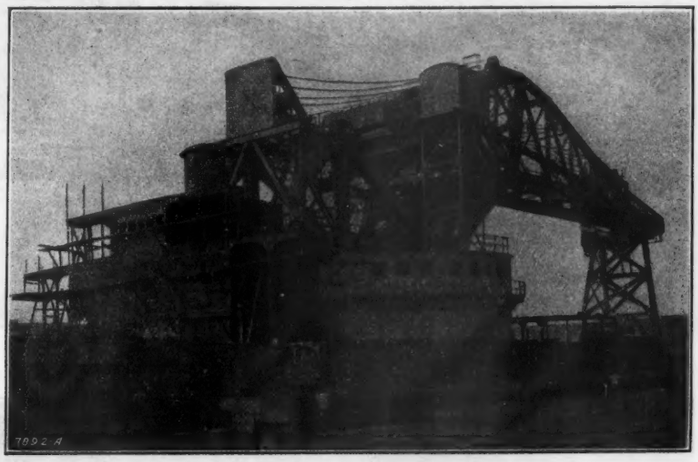


FIG. 2. CRANE SHIP READY FOR SEA.

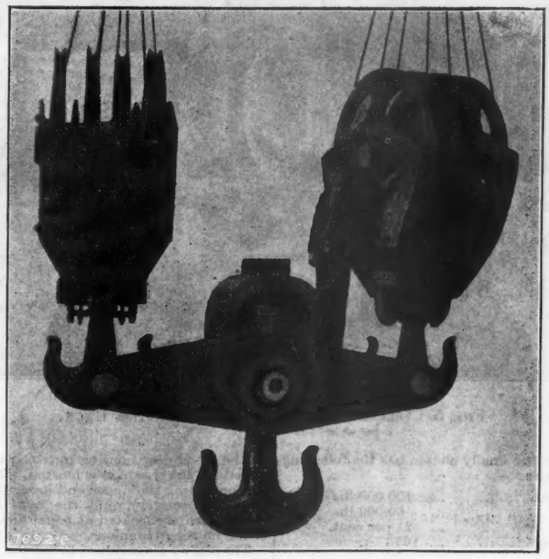


FIG. 3. EQUALISER BAR ON MAIN HOOK.

Special Usefulness of the Large Sea-going Crane.—Cranes of this type are expected to prove useful in many ways. For fitting-out purposes, handling guns, turrets, boilers, &c., they are beyond comparison with any other type as they can be easily moved to any point where their service is required. This is a very decided advantage as it permits the use of a crane not only at different places in the same base but also extends the scope of operations to yards which would otherwise be unable to command such facilities. The utility of a sea-going crane, however, is not limited to work around navy yards and piers. Its value in salvage operations cannot be over-estimated. With the extreme facility of movement possessed by the Kearsarge crane, it is quite possible that a sunken submarine might be salvaged if the work were undertaken before the conditions became too unfavourable. In fact, a sunken tug was salvaged during the war by a 150-ton pontoon crane.

The Kearsarge was built at the Newport News Shipbuilding and Drydock Company yards, Newport News, Va., and was launched on March 24, 1898.

Beginning the Work of Conversion.—After the World War the need of a mobile crane for the use of the Navy became apparent, and the conversion of the Kearsarge into a crane ship was decided upon largely because the hull of the vessel was in an excellent state of preservation and suitable for the purpose in view. At the beginning of the conversion the guns, turrets, much of the armour, the upper works of the vessel, and a number of the boilers were removed. Little was done to the hull, but it was found necessary to widen the beam by the construction of large bulges on the outside of the hull for the purpose of increasing its transverse stability. These bulges are divided into a number of watertight compartments.

Reinforcing the Hull.—In order to carry the immense load and stress imposed by the presence of the crane and possible loads on the upper decks, the whole ship structure had to be materially reinforced. A preliminary calculation showed that the presence of the crane would impose a tangential load of the order of 460,000 lb. acting with a lever arm of 42 ft. 8 in. from the top of the roller path of the crane. So great were these loads that for a while it appeared to be doubtful whether the hull of the ship would be strong enough to withstand their tearing action. The entire structure was accordingly reinforced by an ingenious and liberal use of columns, gusset plates, &c. In this work some interesting expedients were adopted. Thus, the entire main deck consisting of triple plates was, in addition to the usual riveting, electrically butt-welded in such a manner that the top plate is now practically a single piece from end to end.

In the matter of carrying the main deck loads by the vertical partitions, it was found difficult to select a design of angle which would have sufficient metal left after the necessary rivets had been driven in. It was one of the cases familiar in bridge construction of either enough rivets and not enough metal left in the plate, or enough plate and not enough rivets. The problem was solved after preliminary tests in the ingenious way shown in Fig. 1. Here the vertical wall does not quite reach to the horizontal plate, and the angle in addition to being riveted is welded to the vertical plate all along its lower edge. The result is that much of the shear stress is taken off the rivets and transferred to the welded edge, which under these conditions is capable of carrying safely quite a considerable load.

The duty of the Navy Department in reconstructing the hull for the reception of the crane ended with the preparation of the main deck carrying frame for the crane. This latter represented substantially a ring roughly 60 ft. in diameter, the upper surface of which had to be level within very close tolerances. This was made possible by increasing the rigidity of the hull structure by the means referred to above. A rather interesting water level which was rigged up permitted the testing of any number of points on the circular track simultaneously.

Nature of the Engineering Problems Involved.—The engineering problems encountered by the Navy were, however, only a small part of those involved in the construction of the crane proper, this latter having been carried out under contract by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio. Stationary cranes had been built in sizes much larger than the Kearsarge unit and floating cranes of a type much smaller, but never before had it been attempted to complete a floating crane of this size. The Navy specifications demanded that the crane should be capable of withstanding the roll of a ship of the order of 25 deg. complete in 3 seconds, which imposed on every part of the structure an enormous strain. Furthermore, this was to be a seagoing unit, which meant that it might have to encounter rough weather. Every part, therefore, had to be cradled in such a manner that when the vessel was travelling in the open sea there would be no pounding—not an easy proposition with a structure in excess of 40 ft. high above the deck level and weighing millions of pounds. Finally, the crane had to operate on a circular track of 60 ft. mean diameter in a floating structure, that is, one inevitably subject to distortions, and yet remain under perfect control. The whole structure was so large that the manufacture of parts which otherwise would have been merely a matter of routine became a serious engineering problem in itself.

To give but one instance, luffing screws had to be made in sizes 15 in. in diameter and 28 ft. long, while the nuts for them were 5 ft. long, 26 in. in diameter, and about 5,000 lb. each in weight. Every detail of the crane was designed and manufactured in the United States—not because there were any restrictions imposed as to the procurement of parts abroad, but because facilities were available here to do everything to the complete satisfaction of the parties involved, and with excellent success as the tests have shown.

Design and Construction of the Crane.—The Kearsarge crane is of the luffing jib type and is so designed that the jib may be lowered to rest in a cradle at the stern of the ship. (Fig. 2.) In view of the great weight of the crane and the fact that it was to be installed on a seagoing vessel, it was very important to arrange it so that it would be in a perfectly steady position while the ship was under way. To provide for this the crane when not in use is supported at three points. In the first place, it is securely held in the cradle just referred to, which is a substantially built tower. Next, it is held by the centre pin about which it rotates; and finally in the rear, back of the rotating track and under the counterweight, there is a heavy pin held in a rigidly constructed frame. The whole structure is such that the jib cannot move,

* Abstract from the Journal of the American Society of Mechanical Engineers, June, 1923.

notwithstanding the rolling of the ship. The crane is provided with four hooks, two of 125 tons lifting capacity each, one 250-ton compensator-type hook, and a light 40-ton hook on a special trolley for emergency work. Special cradles are provided for these hooks so that when the ship is under way there are no swinging parts.

The operating equipment of the crane consists of two main hoists of 125 gross tons capacity, each operated by separate motors and so arranged that they may be coupled together when handling the maximum load of 250 tons. For this purpose an equaliser is provided which carries a 250-ton hook and is connected by heavy pins to the hooks of the 125-ton blocks. (Fig. 3.) In actual tests 312 tons were lifted. These blocks are suspended by ropes passing over sheaves located at the fixed point of the jib, the reach being varied by luffing the jib.

The Foundation.—The crane foundation is formed by a circular box girder having concentric web plates spaced 4 ft. apart with a mean diameter of 60 ft. This girder is securely built into the hull of the ship and a top flange projects about 2 ft. above the deck and is provided with a heavy cover plate forming a plane surface upon which the crane runway is mounted. This runway consists of four rings of 150-lb. rails spaced in pairs over the webs of the foundation girder. The rails are supported on cast-steel radial chairs secured to the girder and provided with wedges so that the elevation of the rails may be properly adjusted. In order to permit the rotation of the crane about its centre pin without undue friction, the rails are so elevated that the centres of their heads are located on the elements of two cones having their apex at the centre of rotation.

The usual method of operating cranes of this type is by rollers. In this case, however, the diameter of the runway was so large and the loads carried so great that it would have been impossible to retain the rigidity of the track necessary for roller operation. Because of this, a novel construction was evolved, the crane rotating on double-tread cast-steel wheels approximately 30 in. in diameter with treads finished to diameters corresponding to the rolling cones, one side of the cone being, of course, somewhat higher than the other, with a corresponding variation in the elevation of the treads on the track. This may be seen from Figs. 4 and 5 which show the wheels. The wheels are arranged in pairs with each pair carried in a cast-steel equalising-truck frame forming a truck unit. Between the trucks are provided powerful jacks capable of supporting the weight of the entire structure. When the crane is in operation the jacks are, of course, lifted off the track. When the ship is under way at sea and the crane is cradled the jacks support the weight of the structure and thus relieve the wheels from possible pounding in a rough sea, which might result in the production of flats.

The main structure of the crane is built upon two box girders which are 10 ft. deep and 75 ft. long, and have webs spaced 30 in. apart. These girders are supported by the main carrying trucks, four fully equalised units being located under each end of the girders. Intermediate between the main trucks are spring-mounted truck units which are adjusted to take a part of the maximum truck load. Outrigger girders normal to the sides of the main girders are supported over four truck units for the purpose of securing side stability. The centre-pin girder is built between the main girders and extends to within 2 ft. of the deck. The centre pin is secured in this girder and turns in a bearing mounted in a companion girder built into the ship's hull. The centre pin is hollow and the electric conductors supplying power for crane operation pass up through it to rings on the contact column above, from which the current is taken off by brushes.

The counterweight compartment is built between the main girders at the back and contains about 1,000,000 lb. of armour plate secured in place by concrete. This counterweight is proportioned so that the reverse movement with the light jib in its high position is approximately the same as the forward movement with maximum load at full reach. Back stays are built at the rear of the main girders for the purpose of supporting the back luffing nuts. These stays also serve as a support for the hoist rope sheaves.

All the machinery for hoisting and rotating is carried by the main and outrigger girders and is completely enclosed by a circular machinery house which extends below the top of the crane foundation to form a skirt so constructed as to prevent seas from washing over the trucks or foundation.

The Luffing Mechanism and its Operation.—From its lowest position when resting in the cradle to its highest working position the jib revolves about its hinge pins through an angle of nearly 60 deg. This movement is accomplished by large luffing screws operating through the upper and rear nuts previously mentioned. The screws are made of chrome nickel steel and are 15 in. in diameter and 28 ft. long. Two of these screws are coupled together at the centre, one having right-hand and the other left-hand threads so that their rotation tends to increase or diminish the distance between the nuts according to the direction in which they are turned. The threads of the screw are of the buttress type, 4 in. pitch, and the maximum load carried on each screw is 500 tons, which occurs with the load at maximum reach.

The design of these luffing screws was anything but an easy problem. The screws are exposed to such enormous stresses that very great strength had to be put into them and at the same time their size had to be kept down as much as possible in order to reduce the weight of the screw and the size of the luffing nuts, of which more will be said later. Furthermore, the forging of a piece 28 ft. long was a difficult proposition in itself, and any increase in diameter would have materially increased the difficulty of forging. After certain tests chrome-nickel steel was selected and its use made it possible to keep the diameter of the screw down to 15 in.

Special manganese bronze is used for the luffing nuts which are about 5 ft. long, 26 in. in diameter, and weigh about 5,000 lb. each. Each nut is enclosed in a cast-steel housing with trunnions turning in bearings attached to the boom and the back stay, and the design is such that when the jib is at rest on the cradle the lower nut trunnion may be slacked off, relieving the load on the screws and avoiding the possibility of excessive tension which might be produced by the deflection of the ship in a seaway. The selection of the material for these nuts was not easy, as, for obvious reasons, steel could not be used. We are informed that the bronze finally chosen has the following physical characteristics:—

Ultimate strength	...	...	100,000 lb.
Yield-point	...	...	60,000 lb.
Elongation	...	...	24 per cent.
Brinell hardness	...	...	165 ,,

Operation of the luffing screws is controlled by a cross-shaft geared to the screw couplings by bevel gears. This shaft is turned by a spur-gear reduction to the intermediate shaft, which in turn is connected to the motor by herringbone gears. This mechanism is mounted on a machinery floor carried by a luffing strut which is pivoted to the jib midway between the jib hinge and upper luffing nut. (Figs. 6 to 8.) This strut also pivots on a large housing which encloses the screw coupling and the bevel gears midway between the upper and lower nuts.

The strut thus located forms a bisector of two legs of the triangle formed by lines joining the luffing nuts and the jib hinge, and it always maintains the same angle with the horizontal in all positions of the jib; this condition lends itself to the arrangement of the luffing mechanism as the floor of this machinery house is thus maintained horizontal at all times. This fact is also true of the auxiliary trolley mechanism, which is supported by the strut. However, on account of the fact that the relative positions of the strut and the jib are constantly varying, it is necessary to locate the trolley drum on the centre of the lower pivot of the strut, which is of course a point common to both. In this location no change in length of the trolley ropes results as the jib traverses its entire range.

The maintenance of the floor of the machinery house at all times in a horizontal position as referred to above is secured in the following manner: The luffing strut at its upper end is provided with a bearing engaging trunnions on the bevel gear housing in which the coupling for the upper and lower screws is located. This coupling is used for connecting the upper and lower screws, right and left hand, respectively, and the nuts through which the screws turn are located at equal distances on either side of the housing trunnions.

The screws are revolved to luff the jib, and it is evident that any revolution of the screws through the nuts increases or diminishes the centre distance. At the same time the coupling retains its position midway between the nuts. The lower end of the luffing strut is secured by pins to the jib at a point midway between the forward and upper luffing nut and the jib hinge. On account of the fact that the two points of support of the strut are always midway between the points which vary in the course of the luffing function, the strut always remains parallel to the third side of the triangle which is formed by these points, the third side in this case being the backstay. It is therefore evident that any structure forming a part of the strut or built into the strut will maintain a constant angle with the backstay or any portion of the stationary part, and thus will be maintained in a permanent angular relation to the deck.

All the functions of the crane are controlled by one

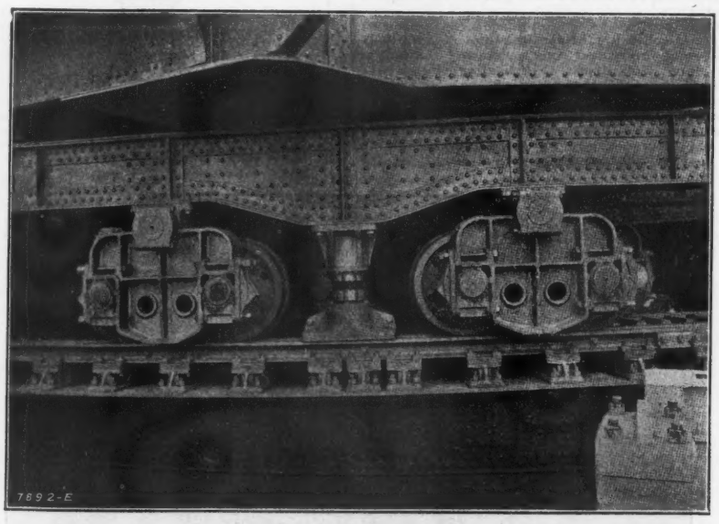


FIG. 4. SUPPORTING TRUCKS AND LIFTING JACK.

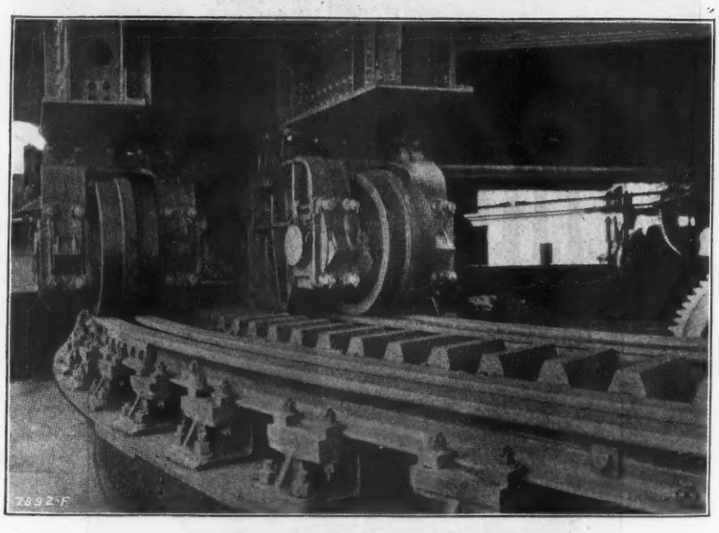


FIG. 5. CRANE TRACK SHOWING OPERATING RACK.

UNITED STATES NAVY CRANE SHIP No. 1.

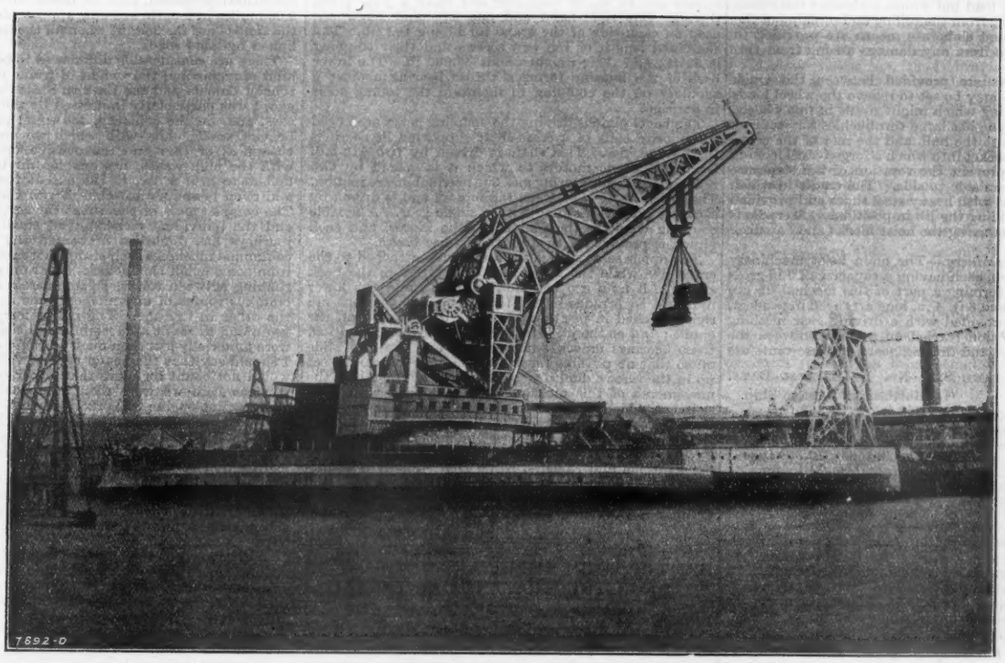
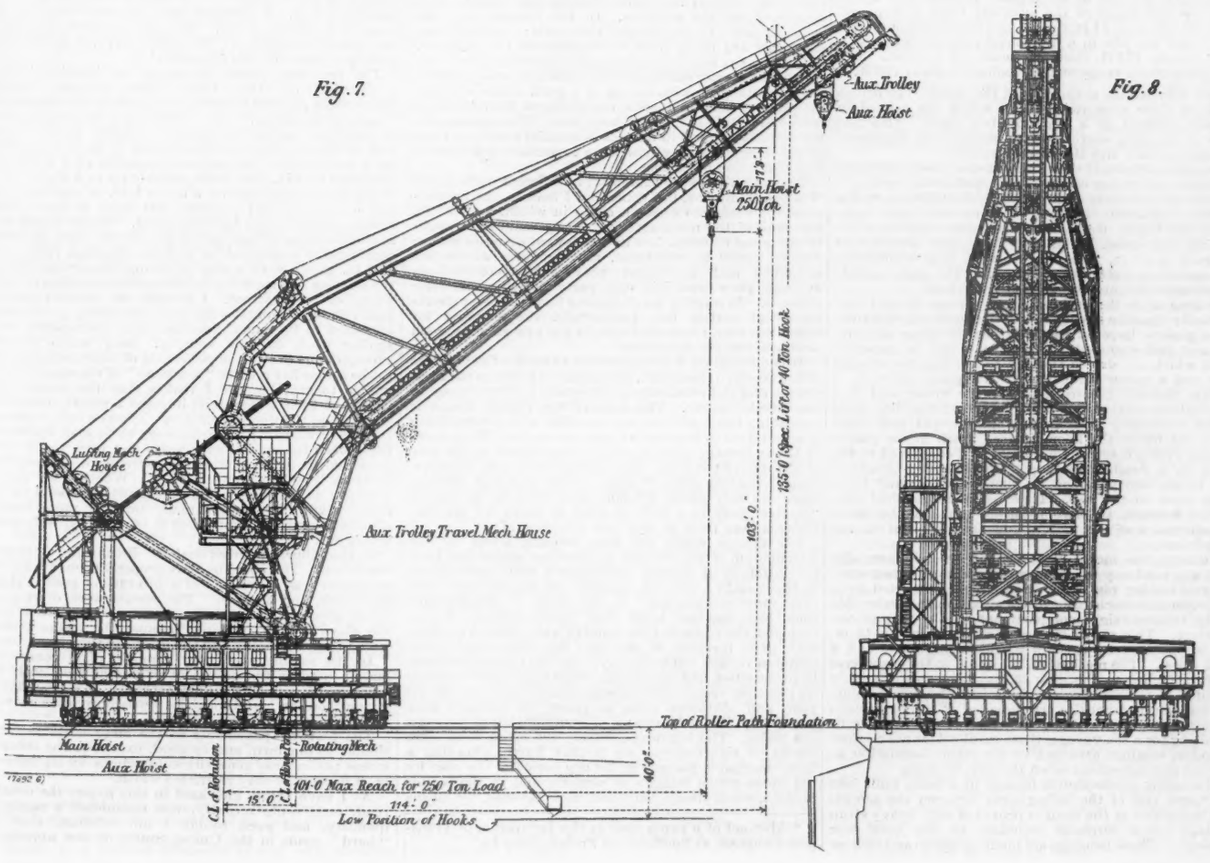


FIG. 6. GENERAL VIEW OF CRANE SHIP.



operator, the various levers for this purpose being located in an elevated cab at one side of the jib.

Prevention of Accidents Due to Rolling of Ship.—One of the important problems in the design of this crane was to so proportion its members that they would not only sustain the working load but would withstand the strain and impacts resulting from the rolling and pitching of the ship when at sea, and elaborate means are provided to protect the machine from any damage arising from this cause.

Heavy jackscrews are provided between the truck units. These jacks may be set to relieve the wheel loads and prevent pounding which might result in flat wheels. Each side of the crane has large turnbuckles for securing the crane structure to the hull, and the rear of the crane is provided with a socket into which a forged-steel locking pin is inserted to prevent the rotation of the structure as the ship rolls from side to side. The cradle in which the jib rests is fitted with heavy steel shoes and provided with clamps for holding the jib in position. A cradle is also provided for receiving the hoist blocks and equaliser when not in use.

The Hoisting Machinery.—The main hoist machinery consists of two units, each having a capacity of 125 gross tons. The drums forming a part of this mechanism are 86 in. in diameter and 8 ft. 4 in. long arranged in tandem, each drum being provided with a driving gear meshing with a common pinion carried on a shaft between the drums. The drums and driving gears of these units are

UNITED STATES CRANE SHIP No. 1—GENERAL DATA.

	Battleship.	Crane Ship.
Length	368 ft.	368 ft.
Beam	72 ft. 2½ in.	92 ft.
Draught	23 ft. 6 in.	10 ft. 7 in.
Displacement ...	11,520 tons	10,350 tons
Speed	16 knots	11 knots
No. of vertical triple-expansion engines ...	2	1

Speeds of Hoists.

Main hoist loaded	6 ft. per min.
Main hoist empty	16 ft. per min.
Auxiliary hoist loaded	15 ft. per min.
Auxiliary hoist empty	30 ft. per min.
Auxiliary trolley	50 ft. per min.
Luffing from high to low position	25 min.
Rotating one revolution ...	9 min.

Ranges of Operation.

Main Hoists :

Radius: Between 72 ft. and 101 ft. from centre of rotation.

Vertical range: From 103 ft. above to 40 ft. below rails on which crane revolves.

Auxiliary hoist :

At 114 ft. radius the auxiliary hook has a vertical range from 135 ft. above the rails to 40 ft. below. With the jib in its highest position the upper vertical range of the auxiliary hoist is increased to 147 ft. at 91 ft. radius, and the maximum reach with the jibs in a horizontal position is approximately 173 ft. from the centre of rotation. The maximum range of the auxiliary hoist is 175 ft.

located between the main gears of the crane. The drums stand on their supporting shafts which are carried in bearings secured to a common bed plate. This bed plate is in turn carried by a substantial structural foundation built into the crane structure.

The pinion shafts of the two hoist units are in accurate alignment and a jaw clutch is provided at the centre to connect the two units when handling the 250 tons on the equaliser. Midway between the curved rails upon which the trucks travel is a bevel-gear rack used for rotating the crane. (Fig. 5.) The pitch diameter of this rack is 61 ft. The teeth are 20 deg. involute in form and have a pitch of about 9 in. The rack is made in sections which are bolted to the rail chairs.

Meshing with the rack are two pinions located diametrically opposite at each side of the revolving structure. These pinions have 12 teeth 20 deg. involute in form, and are half-shrouded. They are keyed to separate shafts which are driven through two reductions of spur gears and a motor train of cut herringbone gears by a 110-h.p. General Electric motor. The motor and first intermediate shaft are mounted on a cast-steel bed plate in the machinery house, while the second and third shafts are below the floor girders. Each motor pinion is fitted with a magnetic disc brake and connected to the motor by a flexible coupling. Double-acting equalised post brakes are provided on each unit operated by a single lever in the cab. There is no mechanical connection between the two rotating units, as the series characteristics of the motors equalises the load on the two pinions.

Although the motor brakes when set will normally resist any tendency to rotate, as an additional precaution a heavy locking pin is provided which is inserted by a hand-operated mechanism into a socket in the under side of the counterweight compartment at the rear of the structure. This pin is of forged steel, 14 in. by 12 in. and is operated by a screw-toggle arrangement and a hand wheel. The mechanism is located in the transverse girder attached to the deck of the ship, and of such a height that the rotating structure just clears in passing.

Four 4-in. turnbuckles are provided at the outer ends of outrigger girder. When the crane is not working or preparing for a sea voyage, these turnbuckles are secured to socket castings attached to the crane foundation to prevent any movement when the ship is rolling.

The luffing mechanism is located in a house built into the upper end of the luffing strut between the screws. The upper end of the strut is provided with heavy strap castings which surround trunnions on the bevel-gear housings. These housings are made in halves and enclose the bevel gears and pinions which turn the luffing screws. The bevel gears are bolted to flanges of nickel-steel couplings, used to connect the upper and lower luffing screws, which are tightly fitted into sockets in the ends of the couplings and secured by wedged keys. The screws are 15 in. in diameter and have a 4-in. pitch thread. One right-hand and one left-hand screw are used on each side of the crane for luffing the jib. The combined length of the two screws and their coupling is 83 ft., and their weight about 45,000 lb. The lower base of the housing forms a thrust bearing against a shoulder on the coupling to maintain the luffing strut in position.

The bevel pinions driving the coupling gears are keyed to opposite ends of a cross-shaft supported in bearings in the housings. This shaft is driven by two 110-h.p. General Electric motors to which it is geared by two reductions of spur gearing and one herringbone reduction. The motor shaft is between the motors and is driven by separate pinions meshing with a single gear. A flexible coupling connects the pinions to the motor, and each pinion is provided with a magnetic disc brake.

The upper screws thread through nuts attached to the crane jibs while the lower nuts are carried in the back stays. All nuts are trunnion mounted, and the lower nuts are so arranged that their trunnion bearings are rigidly locked in position when the jib is raised off the cradle; but as the jib is lowered to its seagoing position, these bearings unlock automatically and the nuts slide off so that no possible tension or compression can be set up in the screws due to weaving of the ship. All of the movements of this mechanism are supplied with limit switches which prevent over-travel. A lever-operated band brake controlled from the operator's cab is attached.

The foregoing account is based on information supplied by the office of Rear-Admiral J. W. Beuret, Bureau of Construction and Repairs, Navy Department, Washington, D.C., officers of the League Island Navy Yard, Philadelphia, Pa., and by the Wellman-Seaver-Morgan Company, Cleveland, Ohio, builders of the crane.

BRITISH AND AMERICAN METHODS IN ROAD CONSTRUCTION AND MAINTENANCE.*

By A. DEYLAND (Member of Council).

THE differences in methods of construction and maintenance of roads as between our island home and the northern portion of the Western Hemisphere are many and various, but they arise, I think, quite naturally from the fundamental differences in physical conditions and in time and order of development.

It appears to me the primary feature to be borne in mind, in accounting for the divergence of practice, is that of the means by which the respective countries have been developed. Our home-land was organised on the basis of a highway system, the gradual growth of many centuries, whereas the United States and Canada were developed by the railways. In the former case, the railways came to supplement the roads; in the latter, the roads are being built to supplement the railways.

In the main, both in Canada and in the States, or at any rate in the greater portion of them, the land was parcelled out in rectangles, with spaces of a good width reserved for public roads, and such development as has taken place has left these rights-of-way clear. This rectangular lay-out has resulted in a series of parallel roads, and one of the difficulties they now have to surmount is that of diagonal communications.

The conditions vary somewhat in different parts of the Western Continent, but generally, I believe, the reservations for roads are about a chain in width, with 86 ft. for some of the main arteries. These conditions apply to the open country, but in the towns, or cities as our cousins prefer to call them, much greater widths are available, and in recent years many commodious avenues have been laid out, particularly in the later growths. In some of the cities, one finds the older streets somewhat narrow but, fortunately, the necessity for width has been recognised and, in the new suburbs, road widths are on generous lines.

It is difficult for a home-dweller to realise the vastness of the Western Continent, the distances between the large towns, and the relatively great spaces between many of the smaller towns. The area of the United States is something like 3,027,000 square miles with a population of about 0·05 to the acre, as against the 121,377 sq. miles of Great Britain with its people distributed at the rate of about 0·72 per acre. The United States has, I believe, some 2,250,000 miles of road, whilst, in Great Britain, there are only about 234,000 miles all told, so that in America there is a mile of road to every 42 persons, whereas here there is only one to every 171.

The change which has been brought about by the introduction of the internal combustion engine has been revolutionary as regards construction and maintenance in this country, but, in America, its effects have been even more momentous. In the stage of development they had reached when this epoch-making change occurred, the cities and the country were distinct entities, with little merging of one into the other, such as is common in this small country. All the industries would be in the cities, and agriculture would only need to convey its principal crops to the towns at certain periods of the year, and, distances being so great, the railways were practically the only means of communication between the cities. The highways outside the cities were mere tracks or rights-of-way on Mother Earth, affording a fairly navigable passage in the dry period of the year by the horse-drawn buggies or wagons, and in the winter months, when frozen hard and snow covered, by means of sleighs. The need for a hard road was, therefore, little felt. When, however, the automobile came, the desire for better road communication in all weathers became an insistent demand, and during the last ten or twelve years great strides have been made in providing good roads. Ambitious proposals, such as ocean to ocean highways, 3,000 miles in length, are now approaching fruition, and the time is not far distant when all the large cities will be linked by good roads.

There are considerable differences to be observed in the kind of traffic and the weight of traffic units. During a tour of Canada and the Eastern States nearly two years ago, I was particularly impressed by the number of light cars, and, on the contrary, the small proportion of the heavier traffic units with which we are familiar. The cheapness of cars and inexpensive operation, coupled with the high wages, has enabled anybody with a few dollars to own a car, to the extent that most artisans and even labourers are able to run their own vehicles. The completeness of the street car service in the towns and the individual ownership of small cars for longer journeys has doubtless prevented the development of communal machines such as our motor omnibuses. Apart from some small single-deck 'buses on pneumatic tyres, running between towns, I came across only two regular omnibus routes of any moment, one in New York, and the other in Chicago. The motor lorry was then only beginning to count appreciably, and the weights of these were materially less than ours. From casual observation I should say that the heavy type of vehicle at that time would not count for more than 5 per cent. of the total, whereas here we were then approaching 50 per cent. The traction engine was practically non-existent, and the steam wagon, or steel-tyred lorry entirely so. It may be said then that the traffic difficulty in the Western Hemisphere is, so far, one of numbers rather than weight. This aggregation of vehicles is a very real difficulty in and around the large cities, both in transit and in storage. A close "procession" is the only adequate description of the method of travel in the large cities and for some few miles outside, and the side streets are full of "parked" cars.

With regard to the cities, as regards construction and maintenance, there is considerable similarity with our own methods. Most of the street car routes are paved with setts, the track being often laid on cross sleepers set in concrete. This is a method which I have not come across in this country, and I do not think it is as good as ours, although I am bound to say it appeared to be more satisfactory than I should have deemed possible. There was, undoubtedly, some occasional displacement of the sett paving arising from movement in, or expansion of, the sleepers due to the access of moisture.

Wood-paved streets are comparatively few, and what I saw did not produce such good results as we attain. I think one reason is the use of hard pine which, like the hard wood so common in this country a few years ago, has the appearance of separate bricks or blocks instead of the "burred" even surface obtained with our creosoted deal. I gathered also they had difficulty in keeping the blocks down. The extremes of temperature and great variation of humidity are, no doubt, the principal causes of this difficulty.

The favourite street pavement in America is undoubtedly what they term "sheet asphalt" which corresponds generally to what is known in this country as "asphalt macadam." It consists of a wearing surface of synthetic asphalt composed of finely graded sands and oil bitumen, laid to a thickness of 1½ in. to 2 in., either on a base coat of bituminous macadam of a minimum thickness of 2 in., but often running up to 5 in. or 6 in., or far more commonly on 6 in. to 8 in. of not very rich but coarsely-graded concrete, left with a very rough surface to form a key for the asphalt. The tendency was in the direction of incorporating with the sheet asphalt a considerable proportion of granite chippings from ¼ in. to ½ in. gauge, with a view to giving greater stability to the wearing surface and minimising the formation of short waves or corrugations. I formed the decided opinion that this sheet asphalt work was particularly good, and it appeared to be much more free from corrugation than similar work in this country. How much of this superiority is due to the perfection of their methods, and to the somewhat greater "hardness" of the matrix, I am unable to say, because I realise that the much lesser weight of their traffic units imposes a greatly decreased stress upon the wearing surface. It was a fact, however, that sheet asphalt pavements were to be seen which had been down for over twenty years and were yet in good condition, notwithstanding the extremes of temperature to which they had been subjected. Whether so "hard" a matrix as they use would be equally successful in this country with its less extreme, but far more humid, climate is open to doubt, but it is, I think, well worth trying out.

In the suburbs, a great deal of "Bitulithic" pavement was in use. This could be more properly termed "asphalt macadam" as it consists of a mixture of graded stone, fine sands, and bitumen. The results were quite good, but it appeared to be more subject to deformation than the sheet asphalt, possibly because the traffic thereon would be more speedy and the reactions therefore greater.

In the smaller cities and hamlets, plain concrete is largely used as the pavement extending frequently the whole width including the tram tracks. It appeared to be giving good service although its appearance was somewhat disfigured by joints and cracks.

The footway pavements in the large cities are very similar to our own, and as good, except in the suburbs, where paving was generally conspicuous by its absence, or, if present, of very restricted width.

As I have before indicated in this paper, the country road, until quite recently, was considered a negligible quantity, and even to-day I am informed that the "hard" roads in the United States do not amount to

* Abstract of a paper read at the Institution of Transport Congress, at Sheffield, on Friday, June 15.

more than 10 per cent. of the length of their public highways. The greater portion are still what is known as "earth" roads—that is, a beaten track on Mother Earth which is occasionally "graded" or "dragged," to level down the inequalities and smooth out the ruts and pot-holes.

There are also "gravel" roads which are kept up by an occasional supply of additional fine gravel which is levelled by dragging, and this process is repeated occasionally after rain, so as to level up the surface. Attempts have been made, in some cases, by oiling the surface, to render them dustless, but the process does not seem to give any very durable result. In some of the States and in Canada, they have also quite good macadamised roads which are treated with oil bitumen in the same way as we generally use tar, but I gather they preferred to use tar for the first dressing, and also in alternate years, as it has penetrating and adhesive properties not possessed by bitumen.

The real hard road programme, however, which has had to be preached up and popularised in order to convert the community to expenditure on public roads—to which they had hitherto been entirely unaccustomed—is mainly concentrated on three methods, viz.: The all-concrete road, the brick road, and the bituminous road. Each kind has its apostles, stimulated in each case by strong and highly-organised trade interests, using all the powers of the press and every known method of publicity to forward the interests of its particular system. We have not yet, I think, reached a stage in which the organisation of particular trade interests is on so complete and universal a scale as in the States.

To return to the "hard road" development; it was realised at the start that, with a huge mileage, it was not possible, in the first instance, to provide a hard surface for any great width, and all the early work was of only 9 ft. width, either of concrete, brick or asphalt; but to allow of passing, the shoulders for some 3 ft. to 6 ft. on either side were made up with gravel or macadam. The American car driver has not been brought up on smooth travel, and the light American car swishes off one wheel on to the rough side, often with a drop of 3 in. or 4 in., and back again and thinks there is nothing to complain of. However, even the American motorist, having tasted the joys of a smooth and firm road, was not satisfied long with the 9-ft. width, and many lengths are being widened to 16 ft., 18 ft. or 20 ft., and most States are endeavouring to set up a standard of 20 ft. for their new construction on important arteries.

It will be realised that these new countries have an immense problem to face in the construction, for it amounts to that, of their entire road system. So few roads having been metalled in the pre-motor days, they have no foundation to build upon, and I think it is one of the main reasons why the all-concrete road has made such great headway. It offered a method of affording at once both foundation and surface, and could be constructed out of comparatively cheap and commonly available material such as river gravel and similar deposits, and without any large proportion of skilled labour. It moreover lent itself to construction with machinery which is so much more used in every operation than with us, stimulated mainly by the necessity to minimise costly labour. I think a consideration of these points brings us to the primary differences between our road system and theirs. Here we have almost universally an old road bed of varying, but yet considerable, strength to build upon; there they had no such advantage. Again we have been slow to adopt the use of machinery, mainly because, until recent years, we had an adequate supply of good and cheap labour, whereas, in the newer countries, labour is both scarce and dear.

The all-concrete road has had an increasing vogue, growing substantially in quantity each year since the war, and is giving good service under the traffic conditions which exist. Whether it will withstand a large increase in the heavier units of traffic has yet to be seen, but American road engineers are alive to the problem they have to face and the State Legislatures readily, on their instigation, pass laws governing the use of roads by vehicles, and define strictly the allowable conditions as to axle weights and speeds. It is, I think, quite certain that more attention is paid to the question of tyring and springing than in this country, with the result that the vehicular traffic of the heavy type gives the road much more chance than with us. Here the gospel is preached that we have to fit the road to the traffic and not the traffic to the road. The Americans think differently, and while they are undoubtedly working to fit the roads to carry a largely-increased amount of heavier units, they are aware there is an economical limit to the expenditure which is justifiable on construction and they keep a tight hand on vehicle development. There is a necessity, both here and there, for building strong roads, but it is not a practicable financial proposition to build all roads of a strength to carry any possible kind of traffic, or any freak vehicle, which may be introduced.

The principal defect of the concrete road is its tendency to crack, arising from the natural forces to which it is subject. The brick road suffers in the same way and from the same cause, and I think with more disintegrating effect. I should say the brick road is not making headway, although it is favoured in the smaller towns and has a very pleasing appearance.

The bituminous road—in various forms—is extending to a great or possibly greater extent than the all-concrete road. The difficulty is to find a foundation on which to lay it. A strong endeavour is made by the "all-bitumen" advocates to fight for a bituminous concrete base with a wearing surface added of finer materials, but I think the tendency, even where bitumen is strongly in the ascendent, is to lay a base 6 in. thick of Portland cement concrete with a 2-in. or 3-in. bituminous carpet thereon.

Herein is a notable difference to our own methods, as most of our bituminous work has been laid on the old macadam base, which has generally been found efficient. The Americans have utilised to a considerable extent the macadam base where it existed, but they are more wedded to the unyielding base principle than we are, hence their preference for concrete either as a surface or, at any rate, a foundation.

In American roads the comparatively broad right-of-way is impressive, but is marred by the narrowness of the hard carriege-way, absence of footways on country roads and general want of finish. The variation in surface between the road pavement and the shoulders, sometimes with a considerable difference of level, makes the road look untidy. It is usual also to have deep ditches at the side of the shoulders without any margin between, which we, in this country, would consider dangerous.

It is only in quite recent years that Americans have realised the necessity for a maintenance organisation. They started out with the idea that, having constructed a length of road, it could be left to take care of itself, not realising that the structure would certainly develop small defects which require speedy attention to prevent extensive deterioration. The "stitch in time" has a specially pregnant meaning to the roadman, and our cousins overseas have now appreciated this and have set up maintenance organisations on very similar lines to those to which we are accustomed.

I have previously said that the Americans are far in advance of ourselves in the utilisation of mechanical appliances, and this applies to every operation in connection with road construction, to such an extent that the American workman does little "hard graft" but is more of a tool operator. The first consideration of the engineer or contractor in designing or carrying out a job is to arrange for the mechanical tools to effect the operation. Undoubtedly mechanical appliances can materially expedite and cheapen the execution of works on any considerable scale, and had it not been for the exceptional circumstances in regard to unemployment from which we have so long been suffering, I have no doubt, greater use would have been made in this country of similar appliances. I think it is mainly in that direction that we can take lessons from overseas.

Another important lesson to which I desire to draw the particular attention of the Institute, is the American organisation for training in highway engineering. Every State has its laboratory for testing and scientific research. Every University has its chair of highway engineering, and every man with any pretentions to call himself a road engineer, at some time in his career, takes a course of study and his diploma at one of the Universities. It is true that such a course of study will not, in itself, make a good engineer, but it should, and undoubtedly does, help materially in the training, and the scientific knowledge so attained, if properly applied, must lead to greater economy than our "rule of thumb" and "trial and error" methods. If this Institute can bring its great influence to bear in the direction of the establishment of highway engineering courses at all our Universities it will, I am sure, be advancing the cause of transport in the most economical manner possible.

NAVIGATION ON THE LAKES OF SWITZERLAND.—Within ten years of Fulton's first Hudson River steamer trips on the Clermont in 1807, the Zürich engineer Bodmer placed the Stephanie on the Lake of Constance; but the engine which was to come from England—as in the case of the Clermont—never arrived for some reason, and the paddle boat Wilhelm Tell was the first Swiss steamer. This, in 1823, took 4½ hours for the journey Geneva-Ouchy, now done in 2½ hours. Other routes were soon opened, also on the Swiss-Italian lakes. At present the largest boats on the Swiss lakes have a length of 70 m. (230 ft.), and carry 1,600 passengers; they are propelled by 1,500-h.p. engines at speeds reaching 32 km. (20 miles) per hour. Altogether 131 steamers and motor boats, aggregating 37,000 h.p., are in service, 100 of which serve for passenger traffic. The first all-Swiss boat was launched by Messrs. Escher Wyss and Co., of Zürich in 1837; later Messrs. Sulzer Brothers, of Winterthur, became powerful competitors in this speciality, and the two firms have also built ships and engines for other waters. The first Swiss Diesel motor boat was constructed by Messrs. Sulzer in 1909.

RAILWAY ELECTRIFICATION IN SWEDEN.—The electrification of the Swedish State Railways, more especially the important Western trunk line, Stockholm-Gothenburg continues to attract keen attention. The cost of the electrification of the latter line, according to the Government proposal of 1920, was calculated at 105,000,000 kroner, of which the actual electrification accounts for 75,000,000 kroner and electric locomotives for 30,000,000 kroner. The work, however, was not taken in hand then, and in the meantime the cost of material has fallen. There are three alternatives, and the one it is now proposed to carry out entails a cost of 38,000,000 kroner, against the 75,000,000 kroner of the previous calculation. Quotations are now much lower, especially for copper, which accounts for about 10 per cent. of the 38,000,000 kroner. With pre-war coal prices and electric energy attainable at 3½ öre, the undertaking should pay its way. The weightiest reason, however, for starting electrification immediately is the fact that the Lilla Edet State hydro-electric power station on the Göta River, somewhat below Trollhättan, is approaching completion, and this was purposely built with a view to railway electrification. The State Telegraphs seem to view the impending railway electrification with some misgivings; they fear that their low voltage currents will be interfered with, but the State Railways guarantee that all necessary precautions will be taken.

CATALOGUES.

Baling Press.—Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham, have sent us a further catalogue of their all-metal hand-operated press for baling waste paper, straw, tin clippings, rags, &c.

Fencing.—A catalogue stating prices of wire and wood fencing, and of posts, gates and all necessary fittings, has come to hand from the Darlington Fencing Company, Limited, 5, Lloyd's-avenue, London, E.C. 3.

Steam Road Rollers.—A 20-page booklet containing illustrations of their steam road rollers at work in many parts of the world has been issued by Messrs. Marshall, Sons and Co., Limited, Gainsborough.

Roller Bearings.—Messrs. Hyatt, Limited, 56, Victoria-street, London, S.W., have sent us additional leaves for insertion in their general catalogue. These contain tables of radial load capacity, fit allowances, and other particulars of the firm's roller bearings.

Underground Cables.—Particulars of armoured cables for laying in the ground without conduits and of cable sections and sheathings, with the necessary connecting fittings are given in a catalogue issued by British Insulated and Helsby Cables, Limited, Prescot, Lancashire.

Roller Bearings.—A few standard sizes of roller bearings at a low price to compete with imported bearings and suitable for colliery wagons and light rolling-stock are listed in a catalogue issued by Gyrol Roller Bearings, 65, Ebury-street, London, S.W. 1.

Switches and Fuses.—A descriptive list of Vanwyks overload switch gears, fuse fittings, and a general revised list of prices has come to hand from the Ironclad Switchgear Company, Limited, 23, Queen Anne's-gate, London, S.W. 1.

Resistance Grids.—A priced catalogue of resistance grids of non-magnetic cast-iron, with graphs showing the temperature rise with different currents, is to hand from Messrs. Ferranti, Limited, 180, Fleet-street, London, E.C.

Roller Bearings.—An excellent catalogue of solid roller bearings, shafting, pulleys and other power transmission accessories, has come to hand from the Empire Roller Bearing Company, Limited, Thornbury, Bradford. The catalogue is fully illustrated, and includes tables of dimensions and prices.

Belt Dressings.—A booklet containing a number of instructive notes on the proper care of driving belts is to hand from Mr. C. R. Averill, 22, Duke-street, Stamford-street, London, S.E., agent for the Joseph Dixon Crucible Company, U.S.A., who include belt dressings among their various products.

Pneumatic Tools.—A leaflet describing an air-driven hand machine for grinding, polishing, wire brushing, &c., is to hand from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1. Detail improvements in the trigger action, hose attachment and lubrication of the tool are referred to.

Stocks and Dies.—A die stock with screwing dies, having a cutting edge for reducing the diameter of oversize material, and another of the self-opening type for pipe screwing, both being hand tools, are illustrated in a catalogue received from Messrs. Stockton and Bunn, Limited, 11, Queen Victoria-street, London, E.C.

Stress Distribution Apparatus.—The apparatus devised by Professor Coker for determining the distribution of stress in structural and machine members by means of polarised light is made by Messrs. Adam Hilger, Limited, 71A, Camden-road, London, N.W. 1, who have issued a catalogue fully describing the appliances and their applications.

Transformers.—A catalogue of electric transformers manufactured at Walthamstow, Essex, by the Swedish General Electric, Limited, in association with the Fuller Electric Manufacturing Company, is to hand from their London Office, 5, Chancery-lane, W.C. 2. The catalogue contains a very full description of the methods of construction, tests, capacities, &c.

Punching and Shearing Machines.—Screw and hydraulic punching bears, lever punching machines, bar and plate shearing machines, machines for mitreing and notching, and a considerable range of power-operated machines of a similar character are illustrated in many designs, and with full particulars of capacity in an excellent catalogue received from Messrs. C. A. Hunton and Sons, 71, Southwark-street, London, S.E. 1.

Water Meter.—A meter suitable for measuring boiler feed water, and made by Messrs. Wilson and Perrett, Limited, Fairfield-street, Wandsworth, London, S.W., is described in a catalogue recently issued by that firm. The meter gives an automatic record of the number of times a measuring tank is filled and emptied—a pair of tanks being employed to ensure a continuous flow. The record appears on a counter and also, if required, on a chart showing gallons per hour.

Internal-Combustion Railway Cars, Locomotives, &c.—The Drewry Car Company, Limited, in association with Messrs. McEwan, Pratt and Co., Limited, 13, South-place, E.C. 2, have sent us catalogues showing the numerous applications of their railway cars, locomotives, &c., propelled by internal-combustion engines. The examples illustrated include hauling locomotives ranging from 200 h.p. to small narrow gauge and shunting engines; railway coaches from 100 h.p. to small cars carrying three or four passengers; and a "portable" motor trolley for running on rails and capable of being rapidly dismantled for transport by road or rail. A wide range of sizes is made of each class of vehicle, many of which are intended for the export trade.

AN INVESTIGATION OF THE BEHAVIOUR OF CERTAIN STEELS UNDER IMPACT AT DIFFERENT TEMPERATURES.*

By F. C. LANGENBERG (Watertown Arsenal, U.S.A.).

(*Concluded from page* 760.)

Experimental Results.—The results obtained in this investigation are shown in Figs. 6 to 17 for the six steels examined in both the annealed and heat-treated condition. A different legend has been used in constructing each curve for convenience of comparison.

Discussion of Results.—Referring to Figs. 6 and 7, it will be observed that Steel A, in the zone of temperatures from — 80 deg. to 0 deg. F., had much more resistance to impact in the heat-treated condition than in the annealed condition. In the range of temperature from 0 deg. to 100 deg. F. the steel in the heat-treated condition also had a greater resistance to impact than the same material in the annealed condition. In the range from 100 deg. to 200 deg. F. there was very little difference. Above 200 deg. F. the steel in the annealed condition gave a higher energy absorption for rupture in the annealed condition than in the heat-treated condition, with the exception of the tests at 1,000 deg. F., where the heat-treated condition was again superior to the annealed condition.

For purposes of comparison certain specific figures will now be given. At a temperature of — 60 deg. F., Steel A in the heat-treated condition had almost twice the resistance to impact as had the same steel in the annealed condition. The steel in the annealed condition rapidly increased its resistance to impact until at a temperature of 0 deg. F. Steel A in the annealed condition gave an average result of 324 ft.-lb. as compared with 466 ft.-lb. for the heat-treated condition. Above 0 deg. F. the impact resistance in the heat-treated condition also improved, so that at 110 deg. F. the average result obtained upon Steel A in the annealed condition was 560 ft.-lb. as compared with 649 ft.-lb. in the heat-treated condition.

In similar manner a great many other comparisons can be made from the two curves, but it is of particular interest to note the great superiority of this steel in the heat-treated condition as compared with the annealed condition in the very low temperature range. It is obvious that the ferrite is very much more finely divided when in the heat-treated condition than when in the annealed condition.

The next discussion will deal with Steel G—a steel utilised in many cases for similar purposes as Steel A, namely, for case-hardened parts, its behaviour being illustrated in Figs. 8 and 9. The essential difference between the two steels lies in the composition, Steel G being a simple carbon steel, whereas Steel A is a nickel-chromium alloy, also containing some 0·04 per cent. more carbon than Steel G. Comparing Steel G in the annealed and heat-treated conditions in the low tem-

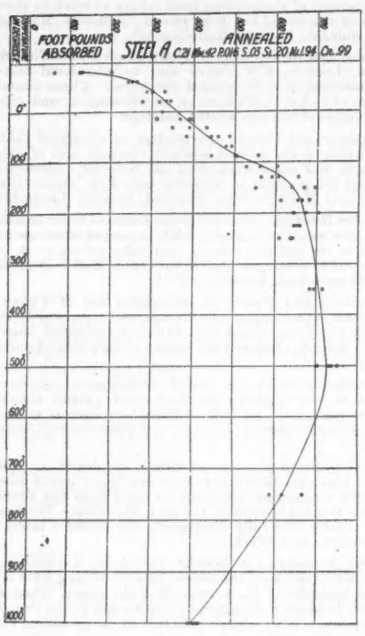


FIG. 6.

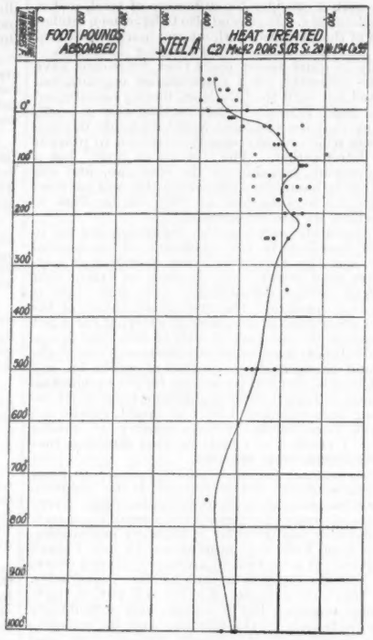


FIG. 7.

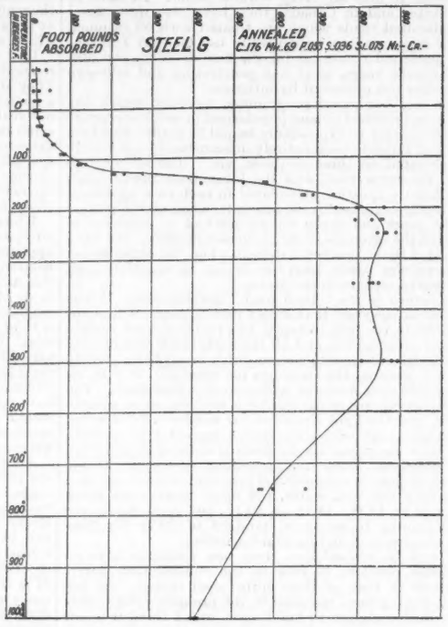


FIG. 8.

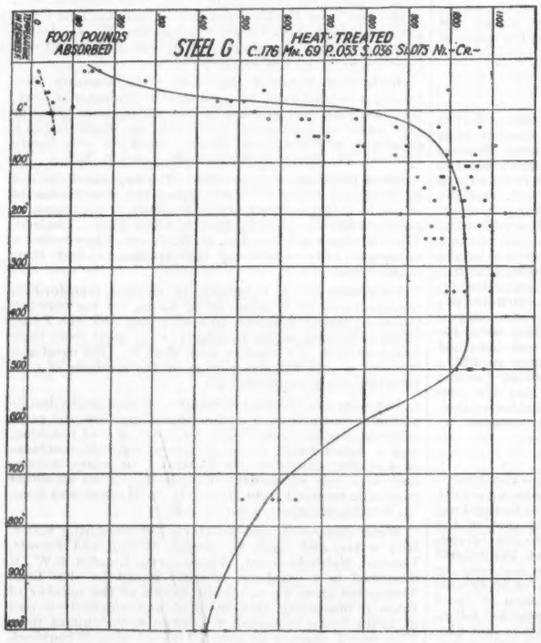


FIG. 9.

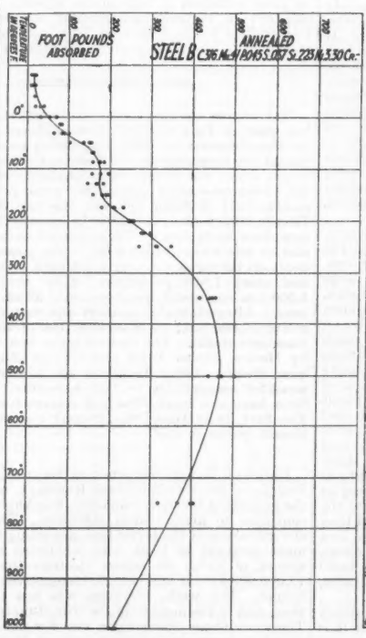


FIG. 10.

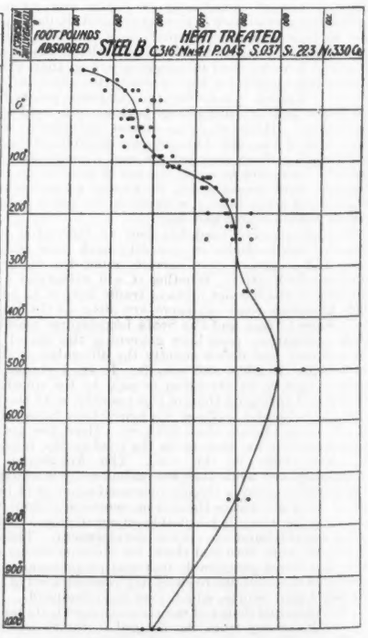


FIG. 11.

ditions. The graph which has been drawn in each case for one condition of the steel, shows the foot-pounds absorbed by rupture which are represented as ordinates, the temperatures of test being the abscissae. The individual results of tests are shown by circles, and the mean of all tests at any temperature is given by the heavy dots. All of the above data have been summarised on two additional graphs, Figs. 18 and 19, the average values of test only being considered, one graph for the steel in the annealed condition and the other for the steel in the heat-treated

* Abstract of a paper read at the meeting of the Iron and Steel Institute on Friday, May 11.

perature range, it will be observed that in the annealed condition no appreciable increase in the resistance to impact is apparent until a temperature of 32 deg. F. is reached. In fact, no decided sharp break in the curve occurs below 90 deg. F. The results obtained upon this steel in the heat-treated condition, however, were very erratic. In some of the temperature tests below 32 deg. F., individual values were obtained varying from approximately 50 ft.-lb. to 1,000 ft.-lb. The lower values appeared to fall on a separate curve, which has been plotted in the form of a broken line, but the average

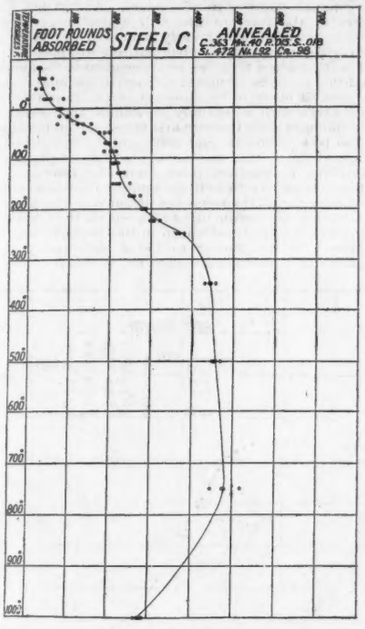


FIG. 12.

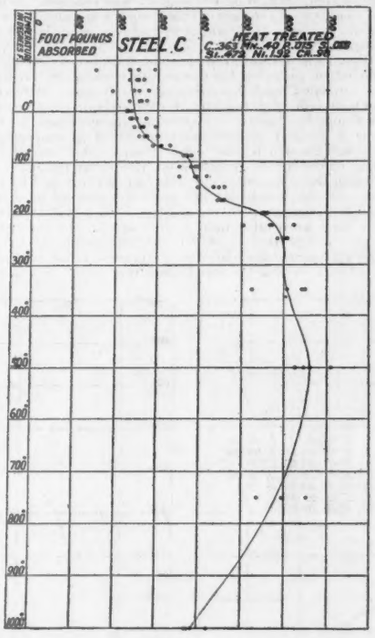


FIG. 13.

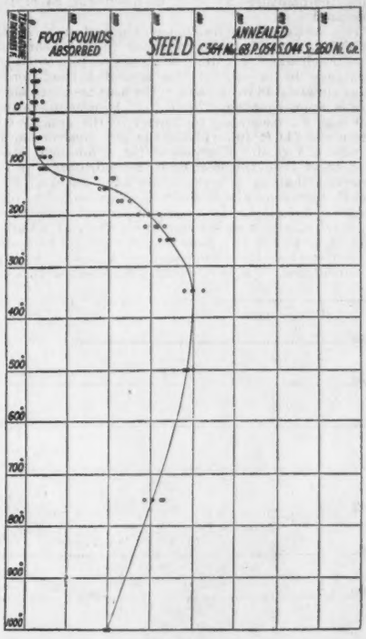


FIG. 14.

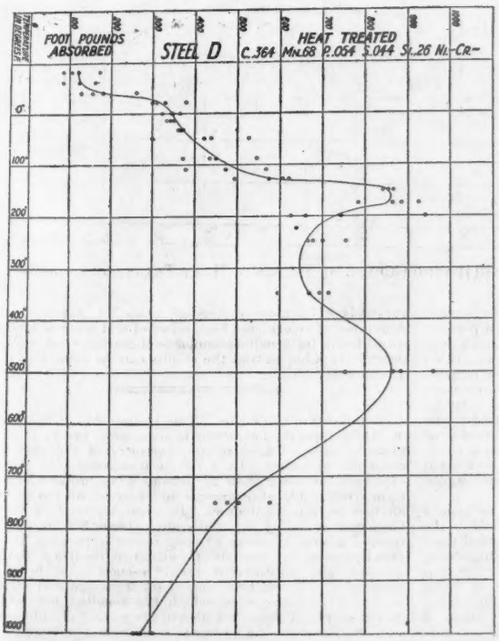


FIG. 15.

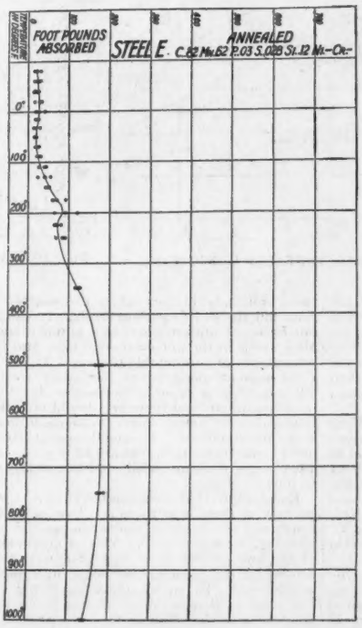


FIG. 16.

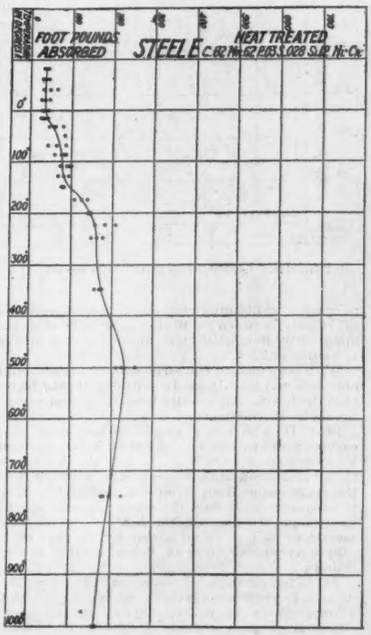


FIG. 17.

of the other tests gave a curve similar to that obtained from the steel in the annealed condition, with the exception that the sharp increase in resistance to impact occurred at a much lower temperature, namely, between — 80 deg. and 0 deg. F., whereas in the annealed condition the same sharp increase occurred between the temperatures 100 deg. to 200 deg. F.

Referring again to Steel G in the annealed condition, attention is invited to the slope of the curve in the vicinity of 70 deg. F., which is the temperature at which practically all routine tests are conducted. The temperature in the laboratory at Watertown Arsenal normally varies from 65 deg. to 80 deg. F., with 70 deg. F. as the approximate average temperature. For the particular steel under discussion, in the annealed condition, a test conducted at 80 deg. F. would give a result approximately 15 per cent. higher than a similar test on the same material at 70 deg. F. In view of the possible rapid change of impact value in the zone of normal temperature, it is very vital that all such tests be conducted at a standard temperature.

Again referring to Steel A in the annealed condition in the temperature range below 100 deg. F. or the normal working range, it is to be noted that much superior values were obtained than in the case of Steel G in a like condition. The average foot-pounds absorbed by Steel G in the annealed condition below a temperature of 0 deg. F. was approximately 25 ft.-lb., whereas for Steel A in the same condition it was approximately 250 ft.-lb. On the other hand, Steel G in the heat-treated condition gave some values much superior to any obtained upon Steel A in the same condition. It is to be noted, however, that in the low-temperature range, namely, from — 80 deg. to 0 deg. F., Steel A was again superior to Steel G.

Regarding the structure of Steel G in the annealed and heat-treated conditions, it would appear that the breaking up of the ferrite by heat-treatment had a marked effect in moving to the left that portion of the curve where the resistance to impact was rapidly increasing. Stated in other words, the breaking up of the ferrite by heat-treatment had decidedly increased the resistance to impact in the lower temperature range.

Figs 10 and 11 represent the curves derived from Steel B, a medium carbon nickel alloy steel. This steel is extensively used in the manufacture of ordnance, and since a great many major and minor calibre guns have been made from a composition not dissimilar, the results are of particular interest. Below a temperature of 0 deg. F. this material in the annealed condition had a very low impact resistance, and in fact would be classed as a brittle material. The same material in the heat-treated condition in the same temperature zone had a decidedly superior resistance to impact.

Three temperatures are selected for the purpose of comparison. At — 80 deg. F. the steel gave an average resistance to impact of 17 ft.-lb., whereas in the heat treated condition it gave 129 ft.-lb. At a temperature of 0 deg. F. the steel gave a resistance to impact of 53 ft.-lb. in the annealed condition, although in the heat treated condition the value was 252 ft.-lb. At 110 deg. F. the resistance to impact in the annealed condition was 177 ft.-lb., while in the heat-treated condition it was 348 ft.-lb.

Again, it is to be observed that heat treatment served

to move the curve to the left on the diagram, eliminating in the heat-treated condition the very low values of resistance to impact which occurred with the steel in the annealed condition.

The contours of curves in Figs. 12 and 13 derived from Steel C, a medium carbon nickel-chromium alloy, are strikingly similar to those of Steel B, a plain nickel alloy. In the annealed condition the resistance to impact in the temperature range from — 80 deg. to 0 deg. F. was very much lower than that exhibited by the same material in the heat-treated condition. Comparisons made at the same temperatures as used in discussing Steel B are presented.

At — 80 deg. F. the resistance to impact in the annealed condition was 27 ft.-lb., whereas in the heat-treated condition it was 231 ft.-lb. At a temperature of 0 deg. F., resistance to impact in the annealed condition was approximately 38 ft.-lb., and in the heat-treated condition it was approximately 228 ft.-lb. At a temperature of 110 deg. F., resistance to impact in the annealed condition was 211 ft.-lb., while in the heat-treated condition it was 378 ft.-lb. Comparing for a moment Steel C with Steel B in the heat-treated condition, it is to be observed that at a temperature of — 80 deg. F. the nickel-chromium alloy, Steel C, was superior to the simple nickel alloy. In a comparison previously referred to, Steel A, also a nickel-chromium alloy, at a temperature of — 80 deg. F., gave superior results to a simple carbon steel at this temperature. Although it may be a coincidence, it is here evident that in the two steels impact can be observed when the steel was in the annealed condition until a temperature of 100 deg. F. was reached. When the steel was in the heat-treated condition an increase in resistance to impact is noticeable in the temperature range from 0 deg. to 100 deg. F.

The heat treatment refines the structure to an appreciable degree. Although a steel of this carbon content is normally expected to give an inferior resistance to impact than steels of a lower carbon content, attention is directed to the steel in the annealed condition, where practically no improvement in impact value was observed until a temperature of 100 deg. F. was reached. When the steel was in the heat-treated condition, improvement began to be noted at temperatures slightly above 0 deg. F.

Figs. 18 and 19 are the consolidated curves previously referred to, prepared for the six steels examined in both the annealed and heat-treated conditions. Referring first to the consolidated curve for the steels in the annealed condition, the fact is evident that three curves do not show a decided upward tendency until a temperature was reached which was higher than in the case of the other three curves recorded on the same graph. Examining the composition of the steels represented by the three curves, which did not show the upward tendency until a higher temperature was reached, it will be found that they were all simple carbon steels. In the range 0 deg. to 100 deg. F., which can be considered as the working range of the majority of steels used in engineering structures, it will be noted that the three alloy steels attention to the fractures exhibited by specimens tested at different temperatures. Considering first Steel A in the annealed condition, a decided crystalline fracture was obtained at — 80 deg. F., the crystalline appearance of the fracture beginning to disappear at 90 deg. F. The fractures at 90 deg. F. showed a crystalline centre with silky edges. At 350 deg. F. the crystalline appearance of the fracture had completely disappeared.

In the case of Steel G in the annealed condition, a simple carbon steel of low carbon content, the fractures were crystalline up to a temperature of approximately 150 deg. F. The fractures at this temperature showed a crystalline centre with silky edges. At 200 deg. F. the centre of the fracture was still crystalline, the silky portion, however, being greatly increased. At 250 deg. F. the crystalline appearance had entirely disappeared.

The fractures of the other test specimens in the annealed condition could be discussed in detail in a similar manner, the general observation, however, being that the specimens broke with an entirely crystalline appearance, the amorphous or silky fracture first appearing on the outside of the test specimens and increasing in amount as the temperature of test increased, gradually replacing the crystalline appearance throughout the fracture. The various typical fractures in the annealed and heat-treated conditions for all the steels are included in this report.

Although not pertinent to this report, it is desired to state that the results obtained in this investigation have appeared to the author to be of sufficient practical application to warrant an extension of this investigation

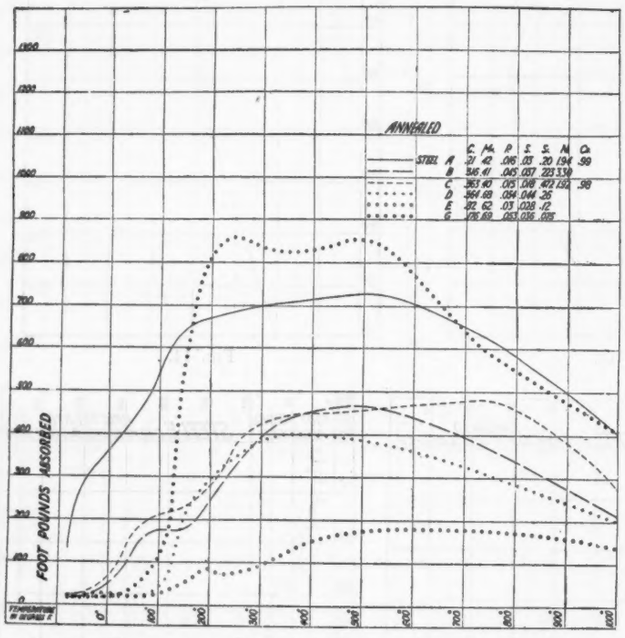


FIG. 18. CONSOLIDATED CURVES OF STEELS IN ANNEALED CONDITION.

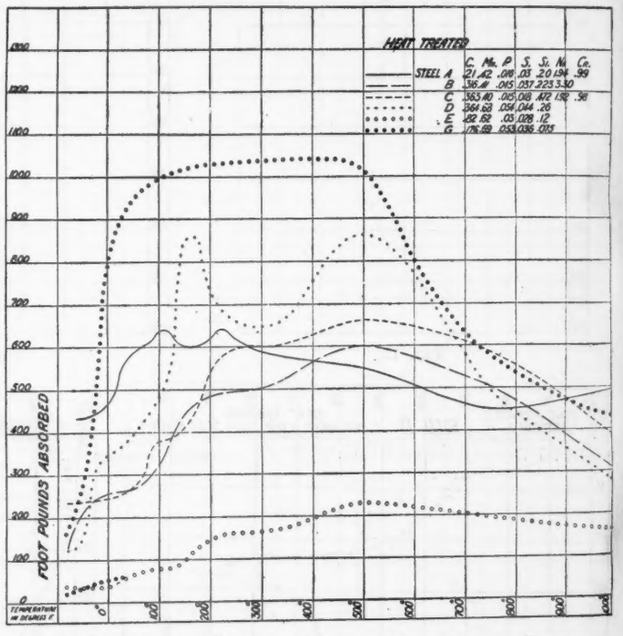


FIG. 19. CONSOLIDATED CURVES OF STEELS IN HEAT-TREATED CONDITION.

referred to containing chromium, the curve does not fall off rapidly between — 40 deg. and — 80 deg. F., but is apparently flat when the materials are in the heat-treated condition.

With reference to the structure of this material in the annealed and heat-treated conditions, it may be remarked that the ferrite is decidedly broken up and disseminated by the heat treatment.

Steel D, which is a simple carbon steel of medium carbon content, can be compared in its two conditions by a consideration of Figs. 14 and 15. This material in the annealed condition was exceedingly brittle throughout the entire range from — 80 deg. to 100 deg. F., increase in resistance to impact not occurring until the temperature range 100 deg. to 200 deg. F. was reached. This behaviour is not at all dissimilar to that of Steel G, also a simple carbon steel, but of a much lower carbon content.

At a temperature of — 80 deg. F., Steel D in the annealed condition gave a resistance to impact of approximately 10 ft.-lb., whereas in the heat-treated condition it gave a value of 122 ft.-lb. At 0 deg. F. the average resistance to impact was 13 ft.-lb. in the annealed condition, and in the heat-treated condition it was 344 ft.-lb. At a temperature of 100 deg. F. the resistance to impact was approximately 40 ft.-lb. in the annealed condition; in the heat-treated condition, on the other hand, it was 474 ft.-lb.

Considering for a moment Steels B, C and D, all of which are medium carbon steels, B containing nickel, C containing nickel and chromium, and D being a simple carbon steel, it is to be observed that both the alloy steels in the annealed condition showed a decided increase in resistance to impact in the temperature range from 0 deg. to 100 deg. F., and at the same time the simple carbon steel showed practically no increase in this zone.

Attention may now be given to Steel E, a steel containing 0·82 per cent. carbon, and a study of Figs. 16 and 17 made. Practically no increase in resistance to gave uniformly higher values for resistance to impact than did the simple carbon steels. It has been pointed out by many authorities that it is not economical to use alloy steels in the annealed condition, and practically no advantages are obtainable thereby. It has been emphasised a great many times that alloy steels have their advantages and superior properties developed only by heat treatment, and therefore should only be used in the fabrication of parts where subsequent heat treatment is to be employed. It would appear from the curve herein presented that certain alloy steels have decided advantages in the annealed condition as regards resistance to impact.

Referring to both consolidated curves, it will be noticed in some of them that there is a loop or falling-off in the resistance to impact in the range not far removed from 200 deg. to 300 deg. F. This is observable in several of the curves, and it is suggested that this effect was caused by the phenomenon commonly known as "blue brittleness." In an investigation earlier conducted by the author, it was found that all the phenomena of fracture in testing a notched specimen were exhibited in so short a period of time that the brittleness resulting from deformation in the "blue heat zone" was apparently unable to develop to any appreciable degree. Specimens deformed at a blue heat and tested at normal temperature by the notched-bar impact test clearly showed the brittleness resulting from deformation at a blue heat. Specimens of the same material, however, tested at a blue heat without previous deformation, did not show the same peculiarity to an appreciable degree. The general shape of some of the curves from material known to be susceptible to blue brittleness was not at all dissimilar to the shape of some of the curves in this report showing the loop in this region. For this reason it is suggested that the falling-off of impact value in some of the instances was possibly due to the phenomenon of blue brittleness.

In concluding the discussion, it is desirable to give to steels of a more diversified range of composition. A number of steels have been selected and are now being subjected to tests on lines similar to those described in this paper. It is hoped that the results can be submitted in a later report.

LIFE-SAVING IN MINES.—The United States Bureau of Mines reports that there is increasing proof of the value of life-saving or rescue apparatus in the case of accidents in mines. In a recent disastrous coal mine explosion no fewer than 22 persons were brought back from irrespirable atmospheres and revived at the fresh air base by waiting doctors. In a number of cases lives have been saved by the men sealing themselves in, to be rescued later. Workers wearing rescue apparatus have penetrated as far as 1,500 ft. ahead of fresh air, have brought out unconscious men, rescued men behind barricades, put out fires, sealed off workings and done a variety of other work which has resulted not only in the saving of lives, but also in the saving of valuable property, and in the prevention of unemployment by making it possible to avoid closing down to flood a mine in order to extinguish a fire, or for other similar reasons. Twenty-three men, or 1·2 per cent. of the number of persons wearing rescue apparatus are recorded as having lost their lives, and four others have been overcome while practising. This number, however, is very small compared with the number overcome while not wearing apparatus. The number of appliances in use is increasing. Several States now require its provision in mines of certain classes. Other States maintain mine rescue stations. Insurance companies grant reduced rates to companies with a proper rescue organisation. There is still much to be done, however, for in the case of 122 recent mine disasters only 32 mines had fully-trained rescue crews. The Bureau of Mines favours the automatic type of apparatus in preference to the appliance providing a fixed supply of oxygen to the wearer.